No. 19. JANUARY. 1908.

Bi-Monthly Bulletin

OF THE

American Institute of Mining Engineers.

PUBLISHED BY THE AMERICAN INSTITUTE OF MINING ENGINEERS

Editorial Office at 29 West 39th Street,

NEW YORK, N. Y.

BI-MONTHLY BULLETIN

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Single copies (including postage), $2 each; to members of the Institute, public libraries, etc., $1 each.

TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

BI-MONTHLY BULLETIN.

SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York City (Telephone number 4600 Bryant).

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* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

MEETING OF THE INSTITUTE.

The XCIVth meeting of the Institute for the reading and discussion of papers will be held in New York, N. Y., beginning Tuesday evening, Feb. 18, 1908. Further particulars will be given in a circular from this office, to be issued before the end of January.

COMPLETE ANALYTICAL AND ALPHABETICAL INDEX OF VOLS. I.—XXXV., INCLUSIVE, OF THE TRANSACTIONS OF THE INSTITUTE.

This volume, an octavo of 626 pages, is now ready for delivery. By its aid, any subject treated or alluded to in the *Transactions* can be instantly tracked. The names of persons, mines, works, towns, etc., have been included; and abundant cross-references and classified sub-headings have been added to facilitate rapid consultation. Thus, the student remembering the name but not the locality, or the locality but not the name, or neither the name nor the precise locality of a gold-mine, can find it under "Gold-mines," or under either of the other heads. For a more extended statement of the nature and use of this Index, which is intended specially for the benefit of those who do not possess complete sets of the *Transactions*, and who consult the Library by correspondence, see the *Bi-Monthly Bulletin* for September, 1907. The price of the Index bound in cloth is $5, delivery charges prepaid. Half-morocco binding costs $1 extra.

Buy at once a copy of this Index, and also as many back-volumes of the Transactions as you can afford. Every such purchase from the stock on hand is so much added to the income of the Institute. As far as possible, the money thus received will be devoted to maintaining and perfecting the Library, and making it useful to members in all parts of the world.

RECEPTION-ROOMS AND BUSINESS HEADQUARTERS FOR MEMBERS AND GUESTS.

A separate room in the suite occupied by the American Institute of Mining Engineers on the ninth floor of the United Engineering Society Building, has been equipped with furniture and telephone extension for the temporary use of members of the Institute or of sister societies, or visitors suitably accredited.

In addition to this general accommodation, another room has been similarly furnished as a business headquarters for a single person, and for a limited period. For the conditions of this privilege, inquiry should be made at the office of the Institute.

In order that the benefit of this arrangement shall not be restricted to a few members only, the period of continued occupancy will be limited, and applications will be considered in the order of their receipt. A small fee will be required for the use of the facilities furnished.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.

The libraries of the above-named Societies open from 9 A.M. to 9 P.M. on all week-days, except holidays.

RULES.

For the protection and convenience of members, the following rules have been adopted:

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room.

This card, as well as any card of introduction given to a non-member, must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

Strangers who desire to enjoy the privilege of entering the alcoves are requested to present either letters of introduction from members, or cards, such as will be furnished upon application by the Secretary of each Society. The first two alcoves are free to all; and admission to the inside alcoves is given upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

SPECIAL INQUIRY.

Do you Possess, or Can you Obtain, and Will you Give, or Sell, to the Institute Library

Early Volumes of the following Proceedings and Journals?

American Chemical Society. *Journal.*
Wanting: Vol. 3, Nos. 8–12 (1881); Vol. 4 (1882); Vol. 5 (1883); Vol. 6, Nos. 1–3 (1884).

American Foundrymen's Association. *Journal.*
Wanting: Vols. 1–4; Vol. 5, Nos. 26, 28–30; Vol. 6, Nos. 31–35; Vol. 7, No. 41; Vol. 8, No. 48.

Australian Mining Standard, Sydney (Australia).
Wanting: Vols. 1–10 (1888–'94); Vol. 11 (1895), No. 370, and all Nos. before No. 356 and all after No. 372; Vol. 13 (1897), Nos. 429, 440, 441, 443, 460, 462, 468, 472, 476; Vol. 13 (1898), 479, 490, 492, 497; Vol. 14 (1898), Nos. 512, 515, 518; Vol. 15 (1899), Nos. 536, 545, 550, 552–554, 557, 559, 562, 566, 567, 581; Vol. 17 (1900), Jan.–June; Vol. 18 (1900), p. 1–425 (July–Oct. 11); Vol. 19 (1901), Nos. 637–639, 647; Vol. 20 (1901), Nos. 661, 662, 680, and p. 543 and index; Vols. 21–30 (1902–'04).

Chemical Society of London. *Journal.*
Wanting: Vols. 1–63, 66–90.

Deutsche Chemische Gesellschaft. *Berichte.*
Wanting: Vols. 1–12 (1868–'80).

Foundry.
Wanting: Vols. 1–22 (1892-1902), and Vol. 23 to No. 133 (1903).

Mining and Scientific Press.
Wanting: Vols. 1–19 (1860–'69); 24–38, 1872–'79 (Jan.–June).

Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde.
Wanting: 1830–'38, 1892–date and general index.

New Zealand Mines Record, Wellington, N. Z.
Wanting: Vols. 1–6 (1896–1902).

Queensland Government Mining Journal.
Wanting: Vols. 1–4.

Revue Universelle des Mines, etc., Liège.
Wanting: Series 1, and Vols. 1–4 of Series 2 (1857–'78); Vols. 2, 9, 11, 15, and 18 of Series 3. Table des Matières de la première et de la seconde série (1857–'76, 1877–'87).

Société de L'Industrie Minérale. *Bulletin.*
Wanting: Series 1, Vols. 1–15; Series 2, Vols. 1–7.

——— ——— *Atlas.*
Wanting: Pts. 2 of Vols. 11, 13, 14; also Pts. 26–33 of Vol. 2.

——— *Compte Rendu.*
Wanting: Jan. to March, 1879, and July, 1900.

Zeitschrift für Angewandte Chemie.
Wanting: Vols. 1-11 (1887-'99); Vols. 15-17 (1903-'09).

R. T. Hill.

Geological History of the Isthmus of Panama and Portions of Costa Rica, in vol. xxviii. of *Bulletin* of Museum of Comparative Zoology. Cambridge.

Geology and Physical Geography of Jamaica, in vol. xxxiv. of *Bulletin* of Museum of Comparative Zoology.

Complete sets of the above publications are greatly needed, as none of them are duplicated in the library of the American Institute of Electrical Engineers or in that of the American Society of Mechanical Engineers.

Please communicate on the above subject with R. W. Raymond, Chairman of the Library Committee, 29 W. 39th St., New York, N. Y.

Accessions.

From November 1 to December 31, 1907.

C. R. Corning and **Robert Peele.**

RIEMER, J. *Shaft-Sinking Under Difficult Conditions.* Translated from the German by C. R. Corning and Robert Peele, xiii, 178 p. il. pl. 8vo. New York, 1907.

[SECRETARY'S NOTE.—The ordinary sinking of mining shafts through rocks of reasonable regularity and firmness, is an operation calling for little more than the application of the principles of excavation, timbering, etc., which are known to all civil as well as mining engineers. While the great majority of mining enterprises continue to offer these ordinary conditions and problems only, it is natural that enterprises involving new, largely unknown, and (to the ordinary engineer) apparently insuperable difficulties, should be passed by in favor of undertakings more certainly feasible—and especially feasible at a cost more accurately to be estimated. Nevertheless, instances now and then occur in which either the great prospective rewards of an enterprise warrant the attempt to deal with special difficulties of development, or such difficulties are encountered unexpectedly, so that either they must be conquered, or the enterprise must be abandoned altogether. The discussion of such problems belongs specially to the department of mining engineering, as distinguished from that kind of mining engineering which is simply civil and mechanical engineering, practiced underground. This treatise, written by Mr. J. Riemer, a mining engineer of Düsseldorf, Germany, and translated by two members of this Institute, is, therefore, a contribution of peculiar value to mining engineering proper. It should be observed that the part of Europe in which the author resides has furnished many of the notable mining problems of this class. According to his own modest preface, his work consists chiefly of a compilation, revision and amplification of previous publications—a circumstance which, in my judgment, increases its practical value. For mining engineers called upon in practice to face such questions

do not want original suggestions half as much as they want intelligent summaries of what has been already tried, and with what results. This book, after a brief preliminary account of shaft-sinking by hand, considers at greater length the Kind-Chaudron system of shaft-boring, giving the particulars as to 79 shafts sunk by this process; the "Poetsch" freezing process, with similar reports of 64 shafts; and, finally, the "drop-shaft" process, which consists essentially in the forcing of a complete shaft-lining through soft ground, and which is illustrated by several German examples. Mining engineers need not be informed of the value of such an intelligent and critical summary.—R. W. R.]

Crossley Bros., Ltd.

CROSSLEY BROS., LTD. *Particulars of a New System of Ammonia Recovery Gas Plant.* 34 p. il. ob. 8vo. Manchester, 1907.

N. H. Darton.

Topographical and Geological Atlas of the Black Hills of Dakota, by Henry Newton. 1879.

Engineering and Mining Journal.

AMERICAN WATER WORKS ASSOCIATION. *Proceedings* of the 27th Annual Convention . . . at Toronto, Canada, June 17–21, 1907. 8vo. 1907.

Annuario della Industria Mineraria, Metallurgica e Chimica Italiana. Year 1. 12mo. Torino, 1907.

AUSTRIA—K. K. ACKERBAUMINISTERIUM. *Die Bergwerks Inspektion in Österreich.* 13th year. 1904. 8vo. Wien, 1907.

CONNECTICUT—GEOLOGICAL SURVEY. *Bibliography of the Geology of Connecticut.* 123 p. 8vo. Hartford, 1907.

HOYT, J. C. and GROVER, N. C. *River Discharge.* 137 p. map. 8vo. New York, Wiley & Sons, 1907.

INDIA—GEOLOGICAL SURVEY. *Records.* Vol. xxxv., pt. 3. 1907.

Jahrbuch für das Eisenhüttenwesen, 1903. Year 4. 8vo. Düsseldorf, 1906.

KEMP, J. F. *The Titaniferous Iron-Ores of the Adirondacks.* p. 377–422 il. pl. map. 4to. Washington, 1906.

MASSACHUSETTS—STATE BOARD OF HEALTH. *Annual Report*, 38*th.* 8vo. Boston, 1907.

MYSORE GEOLOGICAL DEPARTMENT. *Records.* Vol. 6. 8vo. 1907.

NATIONAL CEMENT USERS' ASSOCIATION. *Proceedings of the 3d Annual Convention.* Vol. iii. 8vo. 1907.

Engineering and Mining Journal.

NEW ZEALAND—GEOLOGICAL SURVEY. *The Geology of the Parapara Subdivision.* x, iii p. pl. Maps. 4to. Wellington, 1907. (*Bulletin* No. 3, new series.)

PROVIDENCE, R. I.—CITY ENGINEER'S OFFICE. *Annual Report for* 1906. 8vo. 1907.

SHAMEL, C. H. *Mining, Mineral and Geological Law. . . .* xxx, 627 p. 8vo. New York, 1907.

[SECRETARY'S NOTE.—A more extended expression of my opinion regarding this book has been published in the *Engineering and Mining Journal* of New York. I need only say here that it occupies a middle position between elaborate treatises on economic geology and elaborate treatises on the U. S. Mining Law, furnishing, on the one hand, a sketch of the history and present condition of the science of ore-deposits, and, on the other hand, a compendious summary of U. S. legislation, together with the interpretative decisions of U. S. courts, constituting what is generally called U. S. mining law. In the latter department, it includes due notice of judicial decisions as late as 1907—which is more than can be said of the leading standard treatises on the subject, the most recent editions of which are not so recent as that. The student of economic geology or of U. S. "mining law" will doubtless pursue his inquiries back of this summary to more voluminous and authoritative works. Meanwhile, both those who know already a great deal, and those who know little or nothing, about either of the two subjects named, will find this volume useful.—R. W. R.]

SOCIÉTÉ GÉOLOGIQUE DE FRANCE. *Bulletin.* 4th series, vol. 6, pt. 8; vol. 7, pts. 3–6. 1907.

U. S.—AGRICULTURE DEPARTMENT. *Annual Report of the Office of Experiment Stations for* 1906. Washington, 1907.

U. S.—EDUCATION DEPARTMENT. *Report of the Commissioner of Education,* 1906.

UNIVERSITY OF ILLINOIS. *An Extension of the Dewey Decimal System of Classification Applied to Architecture and Building,* by N. C. Ricker. 101 p. 8vo. Urbana, 1907. (*Bulletin* No. 13.)

U. S.—GEOLOGICAL SURVEY. *Santa Clara Valley, Puente Hills and Los Angeles Oil Districts, Southern California,* by G. H. Eldridge and Ralph Arnold. x, 266, vii p. il. pl. maps. 8vo. Washington, 1907. (*Bulletin* No. 309.)

——— *The San Francisco Earthquake and Fire of April* 18, 1906. vi, 170, i p. il. pl. maps. 8vo. Washington, 1907. (*Bulletin* No. 324.)

——— *Water Supply and Irrigation Papers,* Nos. 195, 197, 208.

Engineering and Mining Journal.

U. S.—WAR DEPARTMENT. *Report of the Chief of Engineers*, 1907.

VIRGINIA—BUREAU OF LABOR AND INDUSTRIAL STATISTICS. *Report*, 1906. 8vo. Richmond, 1906.

WESTERN RAILWAY CLUB. *Proceedings for* 1906–'07. 8vo. Chicago, 1907.

WISCONSIN—GEOLOGICAL AND NATURAL HISTORY SURVEY. *Rural Highways of Wisconsin.* (*Bulletin* No. 18.)

——— *Abandoned Shore Lines of Eastern Wisconsin.* (*Bulletin* No. 17.)

Engineering News Publishing Company.

LEWIS, M. H. and KEMPER, M. *Manual of Examinations for Engineering Positions in the Service of the City of New York.* v. p. il. 8vo. New York, 1906. Price, $5.

[SECRETARY'S NOTE.—This manual gives the civil service rules of the United States, and of sundry States and cities, together with samples of questions, showing the nature of the examinations of candidates for engineering positions. It will be, in my judgment, extremely valuable to such candidates, as well as to all students of our civil service system, the effective operation of which it is calculated rather to enhance than to impair. Similar guides for the use of candidates seeking admission to the bar have long been known ; and I do not think they are regarded as improper aids. In fact, although the publication beforehand of the exact questions constituting a given examination would be, of course, highly reprehensible, it is no more than fair that candidates should be forewarned as to the general nature and range of such an examination. Otherwise, the very best men, widely familiar with principles and practice, might be in danger of appearing ignorant, because they had omitted to prepare themselves on points of relative simplicity, such as beginners are expected to know and practitioners are accustomed to forget, and to "hunt up" when they need them.—R. W. R.]

Institution of Mining and Metallurgy.

INSTITUTION OF MINING AND METALLURGY. *Bulletin* No. 38. 8vo. London, 1907.

McGraw Publishing Company.

RICHARDS, J. W. *Metallurgical Calculations.* Part II. Iron and Steel. 8vo. New York, 1907. Price, $2.00 net.

[SECRETARY'S NOTE.—The practically new science of thermo-chemistry has no more eminent expositor than the author of this book, which continues his discussion of general principles already published, by the application of these principles to the metallurgy of iron and steel, dealing successively with the balance-sheet of the iron blast-furnace ; the calculation of a furnace-charge; the utilization of fuel in the blast-furnace; its heat balance-sheet; the rationale of hot-blast and dry-blast; the pro-

duction, heating and drying of blast; the Bessemer process; its thermo-chemistry, and the temperature-increment in the Bessemer converter; the open-hearth furnace and its thermal efficiency; and the electro-metallurgy of iron and steel. The appendix contains a score of "problems for practice" suited to familiarize students with the application of the principles thus declared. Part III, to appear in 1908, will complete the work by dealing with the application of the same principles to the metallurgy of metals other than iron.—R. W. R.]

Mines Department, New Zealand.

NEW ZEALAND—MINES DEPARTMENT. *Fortieth Annual Report of the Colonial Laboratory*, by J. S. Maclaurin. 8vo. Wellington, 1907.

Mining and Scientific Press, San Francisco.

RICKARD, T. A., Editor. *Recent Cyanide Practice.* 1st edition, 334 [2] p. il. 8vo. San Francisco, 1907.

[SECRETARY'S NOTE.—In this book, Mr. Rickard has compiled the articles on the subject named in the title, which have appeared between January, 1906, and October, 1907, in the *Mining and Scientific Press*, of San Francisco. The list of authors is a large one; and their respective contributions are simply reprinted, without critical discussion of their value. Many of them, however, are authorities and practitioners of such acknowledged eminence as to impart to their statements and opinions an unquestionable weight; and the convenience of such a compilation to the student, who might otherwise be obliged to search the files of Mr. Rickard's journal to find the material here placed at his disposal in a single volume, will be heartily recognized by all busy men. It may be added, that even students are so busy, nowadays, as to be grateful for every aid which diminishes the mechanical part of the labor of research.—R. W. R.]

The New York Edison Company.

THE NEW YORK EDISON COMPANY. *Specifications for the New Waterside Power House of the New York Edison Company*, July, 1907. 420 p. il. 8vo. New York, 1907.

R. L. Polk and Company.

POLK, R. L. AND COMPANY. *National Iron and Steel, Coal and Coke Blue Book.* ed. 3. 974 p. 8vo. Pittsburg, 1907. Price, $10.

[SECRETARY'S NOTE.—This third edition of a well-known and most useful handbook exhibits sundry improvements which increase its value and the convenience with which it may be consulted. One of its most important features (begun in the last edition, but elaborated and perfected in this one) is the introduction of abundant cross-references, with the aid of which the former name of an independent concern, as well as the name of the present company in which it has been absorbed, can be traced. The official directories prepared from time to time by Mr. James Swank, Secretary of the American Iron and Steel Association, remain, of course, the classic authority; but Mr. Swank's last publication of this kind appeared in 1904; and this book is, therefore, highly valuable as

bringing the subject to a later date. Moreover, it covers a wider field, including the producers of coal and coke, as well as of iron and steel. Finally, it contains much collateral information of no little value; and I take the liberty of adding (whatever hypercritical readers may say) that, in my opinion, the numerous advertisements interspersed in it add substantially to its present, as well as its permanent, value.—R. W. R.]

Dr. R. W. Raymond.

CHATARD, T. M. *Salt-Making Processes in the United States.* pp. 491–535 pl. 4to. Washington, 1888.

Extract from 7th Annual Report of the Director of the U. S. Geological Survey, 1885–'86.

Dr. Joseph Struthers.

SYRACUSE CHAMBER OF COMMERCE. *Report Upon Smoke Abatement.* 42 p. 8vo. Syracuse, 1907.

Sullivan Machinery Company.

SULLIVAN MACHINERY COMPANY. *Excavation of Rock by Machinery.* (Catalogue No. 60.) 8vo. Chicago, 1907.

Sydney University Engineering Society.

SYDNEY UNIVERSITY ENGINEERING SOCIETY. *Journal.* Vol. xi. 8vo. Sydney, 1907.

Technische Hoogeschool te Delft (Holland).

VAN ITERSON, GERRIT, JR. *Mathematische und Mikroskopisch-Anatomische Studien über Blattstellungen Nebst Betrachtungen über den Schalenbau der Miliolinen.* xii, 331 p. il. pl. 8vo. Jena, 1907.

Kirby Thomas.

Anexos a la Memoria que Presenta el Ministro de Colonizacion y Agricultura al Congreso Ordinario de 1906. Segunda Parte. 8vo. La Paz, 1906.

Estudio Sobre la Crianza de la Alpaca en el Bais. iii, 33, xxxviii p. 8vo. La Paz, 1906.

Memoria que Presenta el Ministro de Colonizacion y Agricultura al Congreso Ordinario de 1906. 8vo. La Paz, 1906.

Negociacion Minera de San Rafael y Anexas, Mexico y Pachuca, 1907.

WESTON, W. *The Yampa Coal-Field of Routt County, Colorado*, on the Projected Line of the Denver, North-Western and Pacific Railway Company (Moffat Road). 53 p. il. map. 8vo. n. p.; n. d.

Special Mexican Number of the Mining World. 4to. Chicago, 1907.

John Wiley & Sons, New York.

WILSON, E. B. *Hydraulic and Placer Mining.* ed. 2, vi, 355 p. il. 8vo. New York, 1907. Price, $1.25.

[SECRETARY'S NOTE.—This is the second edition of the author's manual, first published several years ago. Mr. Wilson is known also as the writer of handbooks on cyanide processes, the chlorination process, and practical mine-ventilation. The present volume, although not a thorough and comprehensive treatise, but rather a compilation of experience and progress, will be welcome to mining engineers, as a record and guide in a department of engineering in which more ambitious and extensive scientific works are few. Mr. Wilson's summary contains, besides descriptions and tables useful to engineers in practice, many hints and warnings which would benefit ignorant investors—if such investors were not so ignorant!—R. W. R.]

David Williams Company, New York.

BURNS, EUGENE. *Burns Pipe Price Extender.* unp. nar. 16mo. New York, 1906.

FAY, C. H. *The Art of Lead-Burning.* 144 p. il. 8vo. New York, 1905.

Contents: Chapter I. Introduction. II. The Apparatus. III. Hydrogen Gas. IV. Construction of the Generator. V. Making the Gas to Burn the Generator. VI. Connecting the Apparatus. VII. Charging the Generator. VIII. The Flame and Its Management. IX. Different Kinds of Seams. X. Pipe Seams. XI. Acid Chamber Work. XII. Special Hydrogen Apparatus and Burner. XIII. Soft Soldering with the Mouth Blow-Pipe.

HICKS, I. P. *The Estimators' Price Book and Pocket Companion.* 172 p. nar. 16mo. New York, 1906.

JOHNSTON, P. D. *A Manual of Mechanical Drawing.* ed. 2, 149 p. il. pl. sq. 4to. New York, 1907.

KAISER, M. L. *Repair Kinks for Plumbers.* 56 p. il. 12mo. New York, 1905.

KIDDER, F. E. *Strength of Beams, Floors and Roofs, Including Directions for Designing and Detailing Roof Trusses.* viii, 222 p. il. 8vo. New York, 1905.

Contents: Chapter I. Determining the Strength of Wooden Beams. II. How to Determine the Strength or Safe Load of Wooden Floors. III. How to Compute the Size of Floor Timbers for New Building. IV. Types of Wooden Roof Trusses, showing Number and Correct Position of Members and the Action of the Stresses—Triangular and Queen Trusses—Trusses for Flat Roofs—Scissors Trusses. V. Determining the Stresses in Roof Trusses. VI. How to Compute the Size of Truss Members. VII. Proportioning the Joints of Wooden Roof Trusses. VIII. Wind Bracing of Buildings, Towers and Spires. IX. Examples of Truss Construction with Criticisms by the author.

David Williams Company, New York.

ODELL, F. G. *Laying and Finishing Hardwood Floors.* 50 p. il. 12mo. New York, 1906.

SNOW, W. G. *Principles of Heating.* A Practical and Comprehensive Treatise on Applied Theory in Heating. 161 p. il. 8vo. New York, 1907.

Contents: Chapter I. Heating Power of Fuels, Boilers and Combination Heaters. II. Gas, Oil and Electricity *vs.* Coal. III. The Capacity and Fuel Consumption of House Heating Boilers. IV. Furnace Tests. V. Specific Heat. The Heating and Cooling of Air and Humidity. VI. Heat Given Off by Direct Radiators and Coils. VII. The Loss of Heat by Transmission, Computing Radiation. VIII. Heating Water. IX. The Flow of Steam in Pipes and the Capacities of Pipes for Steam Heating Systems and for Steam Boilers. X. Capacities of Pipes for Hot Water Heating. XI. Vacuum and Vapor Systems of Steam Heating.

VOSBURGH, H. K. *Tinsmith's Helper and Pattern Book,* with Useful Rules, Diagrams and Tables. ed. 4, 120 p. il. 16mo. New York, 1906.

PURCHASES.

INTERNATIONAL CABLE DIRECTORY COMPANY. *Western Union Telegraphic Code,* 1907.

THORPE, T. E. *A Dictionary of Applied Chemistry.* 3 vols. New York-London, 1905.

WATTS, HENRY. *Dictionary of Chemistry.* Revised and Entirely Rewritten by M. M. P. Muir and H. Forster Morley. 4 vols. London-New York, 1902, 1905-'06.

TRADE CATALOGUES.

Realizing the value of trade catalogues in a technical library, the Library Committee of the American Institute of Mining Engineers has signified its approval of a plan to strengthen the library along this line. Therefore, manufacturers are asked to place the Library of the American Institute of Mining Engineers on their regular mailing-lists for Trade Catalogues on Metallurgical and Mining Machinery, Mine and Miners' Supplies, Metallurgical Laboratory Equipments, Assayers' and Chemists' Supplies, etc., and also Technical Industrial Catalogues.

All contributions will be acknowledged in the *Bi-Monthly Bulletin.*

American Concentrator Company, Joplin, Mo. N. C. Crushing and Screening Machinery. (*Bulletin* No. 10.)

——— N. C. Differential Motion Jigs. (*Bulletin* No. 11.)

——— N. C. Coal Washing Machinery. (*Bulletin* No. 13.)

——— N. C. Tram Conveyors. (*Bulletin* No. 15.)

Abbé Engineering Company, 220 Broadway, N. Y. Pebble Mills and Various Other Machines.

Abenaque Machine Works, Westminster Station, Vermont. Air Compressor Outfits.

American Spiral Pipe Works, P. O. Box 485, Chicago, Ill. Forged and Rolled Steel Pipe Flanges.

American Steam Pump Company, Battle Creek, Mich. American Power Pumps and Compressors.

——— American Pumping Machinery.

Ansonia Brass & Copper Company, 99 John St., N. Y. Tobin Bronze.

Atlas Engine Works, Indianapolis, Ind. Steam Engines and Boilers (Catalogue, May, 1907).

Backus Water Motor Company, Newark, N. J. Suction Gas Producers and Gas Engines.

Beggs, James, & Company, 109 Liberty St., N. Y. Blackburn-Smith Feed Water Filter and Grease Extractor.

Bishop, J., & Co., Malvern, Pa. Platinum Works.

Blaisdell Company, Park Row Bldg., N. Y. Blaisdell Pressure Filter (Catalogue G).

Butters, Chas., & Company, Ltd., Virginia City, Nev. Butters' Patent Filter. (Catalogue A.)

Chain Belt Co., Park St. and 11th Ave., Milwaukee, Wis. (General Catalogue, No. 35.)

Chicago Concrete Machinery Company, 20 South Canal St., Chicago, Ill. Chicago Concrete Mixer.

Cyclone Drill Company, Orrville, Ohio. The Drill Hole. Vol. 1, Nos. 1-5, 1907.

Dean Steam Pump Company, Holyoke, Mass. Turbo-Generator Condensers. (*Bulletin* No. 42, March, 1907.)

The Deister Concentrator Company, Fort Wayne, Ind. Deister Ore-Concentrator No. 2.

Dole Valve Company, 22 5th Ave., Chicago, Ill. Automatic Air Valve.

——— Automatic Air and Vacuum Valve.

——— Radiator Valve.

ELMORE, A. S. Vacuum-Flotation Process for Concentration. 4 p. 4to, May, 1907.

ELMORE VACUUM ORE CONCENTRATOR at the Cape Copper Company's Mine, Cape Colony, South Africa. Reprinted from *South African Engineering*, June, 1907.

ELMORE VACUUM PROCESS. Standard No. 5, A, Elmore Vacuum Concentrator.

EXPANDED METAL & CORRUGATED BAR COMPANY, St. Louis, Mo. Few Illustrations of Work Done with the Corrugated Bar, 1907.

GARVIN CYANIDE EXTRACTION COMPANY, Portland, Ore., and 56 Wall St., N. Y. Garvin Machines. (*Bulletin* No. 3, 1906.)

GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Tantalum Incandescent Lamps. (Price List No. 5168.)

GOLDEN-ANDERSON VALVE SPECIALTY COMPANY, Pittsburg, Pa. Valves. (Catalogue No. 9, Aug., 1907.)

GOULDS MANUFACTURING COMPANY, Seneca Falls, N. Y. Goulds Efficient Triplex Power Pumps.

GREEN FUEL ECONOMIZER COMPANY, Matteawan, N. Y. Green's Improved Patent Fuel Economizer for Steam Boilers.

HAMILTON MANUFACTURING COMPANY, Columbus, O. Mechanical Loading in Mines.

HENDRYX-ELECTRO CYANIDE COMPANY, 1738 Broadway, Denver, Colo. Description of Apparatus for Cyaniding of Gold and Silver Ores and the Treatment of Copper Ores. (Catalogue No. 3.)

HENDY, JOSHUA, IRON WORKS, 75 Fremont St., San Francisco, Cal. "Davis" Automatic Safety Brake. (*Bulletin* No. 102, Oct., 1906.)

——— Hendy Giants for Use in Hydraulic Placer Mining. (*Bulletin* No. 106, April, 1907.)

——— Pinder Ore Concentrator. (*Bulletin* No. 100, Nov., 1906.)

——— Quartz and Gravel Stamp Mills. (*Bulletin* No. 101, Nov., 1906.)

——— Standard Ore and Water Buckets. (*Bulletin* No. 103, Jan., 1907.)

——— Water Gates, Reservoir Gates and Hydraulic Data. (*Bulletin* No. 105, Feb., 1907.)

HOHMANN & MAURER MANUFACTURING COMPANY, Rochester, N. Y. Hot Water Regulator. (Catalogue.)

HUNT, C. W., COMPANY, 45 Broadway, N. Y. Coal Handling Machinery. (Catalogue No. 072.)

——— Introduction to their General Line of Machinery. (Pamphlet No. 073.)

INDUSTRIAL GAS COMPANY, N. Y. Harvey Anthracite Producer Gas Plants. (*Bulletin* No. 16, July, 1907.)

INGERSOLL-RAND COMPANY, 11 Broadway, N. Y. Diamondless Core Drills.

——— Temple-Ingersoll Electric-Air Rock Drill. (Catalogue No. 383.)

JEFFREY MANUFACTURING COMPANY, Columbus, O. Care of Electric Mine Locomotives in Service. (*Bulletin* No. 12, March, 1907.)

——— Coal and Ashes Handling Machinery for Power Plants. (Catalogue D, *Bulletin* C.)

——— Grab Buckets and Coal and Ashes Handling Machinery for Power Houses. (*Bulletin* B.)

——— Conveying Machinery for Saw Mills, Lumber Mills and Wood-Working Industries. (No. 57 B.)

——— Screens. (Catalogue 69 A.)

JENKINS BROS., 71 John St., N. Y. Catalogue and Price List. Valves and Packing, 1907.

KNECHT BROTHERS COMPANY, Cincinnati, O. The Knecht Drill.

LATTA & MARTIN PUMP COMPANY, Hickory, N. C. Pumps.

LORD & BURNHAM COMPANY, 1133 Broadway, N. Y. Sash Operating Apparatus.

McCALL FERRY POWER COMPANY, 60 Wall St., N. Y. Electric Power from the Susquehanna River. (*Bulletin* No. 3, June, 1907.)

MILLIKEN BROTHERS, 11 Broadway, N. Y. Structural Steel. 1906.

MINE & SMELTER SUPPLY COMPANY, Denver, Colo. Wilfley Concentrator, No. 5. (*Bulletin* No. 6.)

——— Wilfley Slime Table No. 2. (*Bulletin* No. 8, May, 1905.)

MOORE, C. C., & COMPANY, San Francisco, Cal. Method for Calculating Steam Power-Plant Economy, by C. R. Weymouth, ed. 2, Jan., 1907.

MORIN, H., 11 Rue Dulong, Paris, XVII. Instruments de Précision.

NEW YORK ENGINEERING COMPANY, 2 Rector St., N. Y. The Empire Hand Prospecting Drill.

OPEN COIL HEATER & PURIFIER COMPANY, Indianapolis, Ind. Stickle Open Coil Heater and Purifier.

——— ——— Testimonials.

PARRISH, EDWARD, Newport, R. I. Parrish Continuous Filter, July, 1907.

ROCKWELL ENGINEERING COMPANY, 26 Cortlandt St., N. Y. Annealing and Hardening Furnace with Oil Burning Outfit (No. 2).

——— Bolt Heating Furnaces (No. 11).

——— Flue Welding Furnace (No. 3).

——— Fuel Oil Burning Appliances (Catalogue F).

——— Heating Machines for Annealing, Hardening, Tempering, Etc. (No. 9.)

——— Rivet Heating Furnaces (No. 4).

——— Rod Heating Furnaces (oil or gas fuel) (No. 10).

SCHIEREN, C. A., & COMPANY, 30 Ferry St., N. Y. The Belt Book, Oct., 1907.

SHEPPARD, C. E., COMPANY, 63 Cliff St., N. Y. Improved Tengwall File (for binding).

SIMPLEX CONCRETE PILING COMPANY, Tacony, Philadelphia, Pa. Simplex Concrete Pile Foundation Wharf and Trestle Systems.

STEPHENS-ADAMSON MFG. COMPANY, Aurora, Ill. Conveying and Transmission, Vol. 2, Nos. 2–4; Vol. 3, Nos. 2 and 5, 1907.

STEWARD & ROMAINE MFG. COMPANY, 124 N. 6th St., Philadelphia, Pa. (Catalogue No. 29.)

STREETS WESTERN STABLE CAR LINE, Chicago, Ill. Manufacturers of all Classes of Wooden Freight Cars, 1907.

STURTEVANT MILL COMPANY, Boston, Mass. Balanced Crushing Rolls (Series 100).

——— Balanced Crushing Rolls (Series 107).

——— Crushing Rolls.

——— Fine Crushing (Series 104).

——— Fine Crushers (Series 99).

——— Gyratory Breaker (Series 106).

——— Newaygo Separator (Series 105).

——— Roll Jaw Crushers.

SULLIVAN MACHINERY COMPANY, Chicago, Ill. Sullivan Diamond Core Drills. (Catalogue No. 55.)

——— Mining Hoists (*Bulletin* No. 56).

——— Modern Practice in Air Compression. (Catalogue No. 58).

TAYLOR BROTHERS COMPANY, Rochester, N. Y. Verschoyle Patent Transit, 1907.

THOMAS, A. S., COMPANY, 1200 Walnut St., Philadelphia, Pa. Analyzed Chemicals.

THOMPSON BALANCE COMPANY, Denver, Colo. Balance and Weights of Precision for Metallurgists and Chemists, 1907.

UNITED STATES MCADAMITE METAL COMPANY, 18 Rapelye St., Brooklyn, N. Y. What is McAdamite Metal?

UNITED STATES METAL REDUCTION COMPANY, Seattle, Wash. Ore Separation.

UNITED STATES STEEL PILING COMPANY, Chicago, Ill. Steel Sheet Piling.

UNIVERSAL PORTLAND CEMENT COMPANY, Chicago–Pittsburg. Universal Portland Cement, 1907.

UTAH MINING MACHINERY & SUPPLY COMPANY, Salt Lake City. Callow's Settling and Pulp Thickening Tank. (*Bulletin* No. 400.)

——— Callow's Traveling Belt Screen. (*Bulletin* No. 300.)

VEREINIGTE MASCHINENFABRIK AUGSBURG UND MASCHINENBAUGESELLSCHAFT NÜRNBERG, A-G. Nürnberg Gas Engines. (Catalogue No. 9.)

WESTERN ELECTRIC COMPANY, Chicago, Ill. Hawthorne Works for the Manufacture of Power Apparatus.

——— Motor Driven Exhaust Fans. (*Bulletin* No. 5351.)

WOOD, R. D., & COMPANY, Philadelphia, Pa. Centrifugal Pumping Machinery, 1906.

SERIAL PUBLICATIONS IN THE LIBRARY OF

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—AIEE.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—ASME.
AMERICAN INSTITUTE OF MINING ENGINEERS—AIME.

To December 31, 1907.

All current serials which are taken by the three libraries, as indicated, are here represented. The list does not contain, however, a complete inventory of all non-current serial publications, but only those which are duplicated in one or more of the three libraries.

It was compiled for the convenience of members who have no direct access to the valuable files of scientific and technical periodicals herein mentioned, in the hope that they would find it useful for reference.

Académie des Sciences, Paris. Comptes Rendus, W. 1—, 1835–date, AIEE; V. 118–date, 1894–date, ASME.

———. Mémoires, 1796–date, AIEE.

Academy of Natural Sciences, Philadelphia. Proceedings, Irreg. 1—, 1871–date, AIME.

Age of Steel, W. 85–92, 1899–1902 (Merged with Iron and Steel in 1903 and continued as Machinery World, St. Louis), ASME.

Alabama—Geological Survey, Montgomery. Bulletin, 2—, 1892–date, AIME.

American Association for the Advancement of Science, Salem. Proceedings, Y. 1, 21, 26–, 1849–date, AIEE; 1—, 1849–date, AIME.

American Ceramic Society, Columbus. Transactions, Irreg. 1—, 1899–date, ASME; 3—, 1901–date, AIME.

American Chemical Society, Easton. Journal, M. 18—, 1896–date, AIEE; 1—, 1879–date (except V. 3, Nos. 8–12; V. 4–6; V. 6, Nos. 1–3), AIME.

———. Chemical Abstracts, No. 1–date, Jan., 1907, AIME.

American Electrician, New York, W. 1—, 1890–1905, 14–16, AIEE; 1902–1904, ASME. (Consolidated with Electrical World, 1906.)

American Engineer, New York, M. Current Year only, AIEE; 1887–date, AIME; ASME.

American Foundrymen's Association, New York. Transactions (Formerly Journal). 10—, 1901–date, ASME; 9—, 1898–date, AIME.

American Gaslight Journal, New York, V. 12, 14–55, 69–, 1870–date, AIEE; 1896–date, ASME; 1879–'83, AIME.

American Geographical Society, New York. Journal, 2, pt. 2, 7–32, 1870, 1875–1900, AIME.

American Geologist, Minneapolis, M. 1—, 1890–1905, AIME. (Merged with Economic Geology 1906.)

American Institute of Architects, Washington. Proceedings, 27—, 1893–date, AIEE; 1892, '94 and 1902, ASME 31–, 1897–date, AIME.

———. Quarterly Bulletin, 1903–date, AIEE; 1900–date, AIME.

American Institute of Electrical Engineers, New York. Transactions, 1—, 1884–date, AIEE; ASME; 5—, 1887–date, AIME.
———. Proceedings, AIEE; ASME; AIME.
American Institute of Mining Engineers, New York. Bi-Monthly Bulletin, 1—, 1905–date, AIEE; ASME; AIME.
———. Transactions, Y. 1882–date, AIEE. 1—, 1871–date. ASME; AIME.
American Inventor, Washington-New York, S.-M. 1900–date, AIME.
American Iron and Steel Association, Philadelphia. Annual Statistical Report, 1879–date, AIME; 1881–89, ASME.
———. Bulletin, B.-W. 1880–date, AIME.
American Journal of Mathematics, Baltimore, Q. 2–6, 8–date, 1879–date, AIEE.
American Journal of Science, New Haven, M. 1—, 1818–date, AIEE; AIME.
American Machinist, New York, W. Current year only, AIEE; 3—, 1880–date, ASME; AIME,
American Manufacturer and Iron World, Pittsburg, W. 1876–1907, AIME (Changed to Industrial World, 1907.)
American Marine Engineer, Chicago, M. March, 1907–date, ASME.
American Miller, Chicago, M. 1886–date, ASME.
American Mining Congress, Denver. Report of Proceedings of Annual Session, 2, 4, 6–9, 1898–date, AIME.
American Museum of Natural History, New York. Annual Report, 1882–date, AIME.
———. Bulletin. Irreg. 1—, 1881–date, AIME.
American Philosophical Society, Philadelphia. Proceedings (8 numbers yearly), 1—, 1840–date, AIEE; Nos. 92–date, AIME.
———. Transactions, 1786–1881, AIEE.
American Physical Society, Ithaca. Bulletin, Q. 1899–1902, AIEE.
American Railway and Master Mechanic's Association, Chicago. 1868–72, 1874–date, ASME.
American Railway Engineering and Maintenance of Way Association, Chicago. Proceedings, Y. 1900, AIEE; 1901–1902, ASME.
American Society for Testing Materials, Philadelphia. Proceedings, Y. 1—, 1899–date, AIME; ASME.
American Society of Civil Engineers, New York. Proceedings (10 numbers a year), 1888–date, AIEE; 1873, 1894–date, ASME; 1876–date, 1—, AIME.
———. Transactions, Y. 1888–date, AIEE; 1—, 1868–date, ASME; 2—, 1874–date, AIME.
American Society of Heating and Ventilating Engineers, New York. 1895–1904, AIEE; 1895–date, ASME.
American Society of Mechanical Engineers, New York. Proceedings, M. 1907–date, AIEE; ASME; AIME.
———. Transactions, Y. 1—, 1880–date, AIEE; ASME; AIME.
American Society of Municipal Improvements. Proceedings 12th Annual Convention, Montreal, 1905, ASME.
American Society of Naval Engineers, Washington. Journal, 1889–date, ASME.
American Street Railway Investments, New York, Y. V. 1–3, 6, 8–, 1894–date, AIEE.
American Telephone Journal, New York, W. 1902–date, AIEE.
American Water Works Association, Elmira. Reports, 1883, '84, '86, '88, '91–1903, ASME.
Analyst (The), London, M. 1907–date, AIME.
Annalen der Physik, Halle-Leipzig, M. 1—, 1790–date, AIEE; 1895–97, '99–1900, 1900–date, ASME.

Annales de Chimie et de Physique, Paris, M. 1—, 1789–date, AIEE; 1894–97, 1899–date, ASME.

Annales des Mines, Paris, M. 1—, 1817–date, AIME.

Annales des Mines de Belgique, Bruxelles, Q. 1903–date, AIME.

Annuaire du Bureau des Longitudes, Paris, 1833, 1879, 1897–1903, 1906–date, AIEE.

Architekten und Ingenieur-Vereins Zu Hannover. Zeitschrift, 6 nos. yearly. New series. 10—, 1903–date, AIME.

Architectural Record, New York, M. 1907–date, AIME.

Association Amicale des Ingénieurs Electriciens, Paris. Bulletin, 1902–date, AIEE.

Association de Ingénieros y Arquitectos de Mexico. Anales, Irreg. 1886–date, AIME.

Association des Ingenieurs de Gand, Bruxelles. Annales, 1892–date, ASME.

Association des Ingénieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, Liége. Bulletin, 1899–date, AIEE.

Association of Engineering Societies, Philadelphia-Boston. Journal, M. Vol. 7–date, AIEE; 1–date, 1881, ASME; 2–date, 1883, AIME.

Association of Railway Telegraph Superintendents. Proceedings, Y. 1888–1905, AIEE.

Associazione Elettrotechnica Italiana, Rome. Atti, B.-M. 1898–date, AIEE.

Australasian Institute of Mining Engineers, Melbourne. Proceedings, Irreg. 1—, 1901–date, AIME.

——. Transactions, Y. 1894–date, AIME.

Australian Mining Standard, Melbourne, W. 1895–date, AIME.

Austria-Kaiserlich-Königliche Ackerbauministeriums, Wien. Bergswerks Inspektion, Berichte, 1897–date, AIME.

——. Statisches Jahrbuch, 1895–date, AIME.

Automobile, New York, W. 1906–date, ASME.

Automobile Topics, New York, Current Numbers, ASME.

Automotor Journal, London, W. 1897–date, AIEE; ASME.

Beiblatter zu Annalen den Physik. Leipzig, M. 1877–date, AIEE.

Berg u. Hüttenmannisches Jahrbuch der Kaiserliche Königlichen Bergakademic zu Leoben und Pribram, Wien. 1869–date, AIME.

Black Diamond, Chicago, W. 1888–date, AIME.

Boletin de Minas, Lima, M. 1886–date, AIME.

Boston Book Company. Bulletin of Bibliography, Q. 1904–date, AIME.

Boston Society of Civil Engineers. Bulletin, M. May, 1906–date, ASME.

Boston Society of Natural History. Proceedings, Irreg. 1876–date, AIME.

Brass World and Plater's Guide, Bridgeport, M. 1905–date, AIME.

British Association for the Advancement of Science, London. Reports, Y. 1831–1838, 1841–77, 1900–1901, AIEE; 1831–1838, 1841–1899, AIME; 1858, ASME.

British Columbia Bureau of Mines, Victoria. Annual Report, 1877, 1894–date, AIME.

British Columbia Mining Record, Victoria, M. 1895–date, AIME. (Except V. 3–4; 5, Nos. 2–12; V. 6–7; 8, Nos. 1–6 and 8.)

British Guiana—Department of Lands and Fisheries, Georgetown. Reports, Irreg. 1902–date, AIME.

British Society of Mining Students, Bristol, Eng. Journal, Irreg. 1907–date, AIME (changed to British Federated Society of Mining Students, 1907.)

Bulletin des Usines Electriques, Paris, M. 1896–1903, 1906–date, AIEE.

Buyers' Reference, Electrical, New York, Q. Oct., 1901, April, July, Oct., 1902, Jan., Oct., 1903, Jan., July, Oct., 1904, Jan., Apr., Oct., 1905, Jan., 1906–date, AIEE.

California Academy of Sciences, San Francisco. Memoirs, Irreg. 1903, AIME.

———. Proceedings, Irreg. V. 2, 3, pt. 3; Ser. 2, V. 1–6; Ser. 3, V. 1–date, 1858–date, AIME.

California Journal of Technology, Berkeley, M. 1903–date, AIME.

California Miners' Association, San Francisco. Proceedings of the Annual Convention, 1894–date (except V. 1–2, 4–6), AIME.

California—State Mining Bureau, San Francisco. Bulletins, Irreg. 1888–date, AIME.

Canada—Geological Survey, Montreal-Ottawa. Annual Report, 1885–date, AIME.

———. Summary Report, 1869–date, AIME.

———. Mineral Statistics and Mines Division, Annual Report, 1890-date, AIME.

Canada—Patent Office, Ottawa. Canadian Patent Office Record, M. 1901-date, AIEE; 1885–date, AIME.

Canadian Electrical Association, Toronto. Proceedings, 1900, 1902–date, AIEE.

Canadian Electrical News and Engineering Journal, Toronto, M. 1894–date, AIEE; 1896–date, ASME.

Canadian Engineer, Metal Trades Journal and Electrical Science Review, Toronto-Montreal, M. 1900–date, ASME.

Canadian Institute, Toronto. Proceedings, Irreg. 1838–1900, AIME.

———. Transactions, Irreg. 1889–date, AIME.

Canadian Manufacturer, Toronto, B.-M. 1897–date, ASME.

Canadian Mining Institute, Ottawa. Journal, Y. 1898-date, AIME; 1899–date, ASME.

Canadian Mining Journal, Toronto-Montreal, S.-M. 1907–date (Continuation of Canadian Mining Review), AIME.

Canadian Mining Review, Ottawa, M. 1889–1907 (Continued by Canadian Mining Journal), AIME; 1897, 1899, 1904, ASME.

Canadian Society of Civil Engineers, Montreal. Reports of Annual Meetings, 1892–date, AIME.

———. Transactions, Irreg. 1887–date, AIEE; AIME; 1899–date, ASME.

Cape of Good Hope—Geological Commission, Cape Town, Annual Report, Y. 1898–date, AIME.

Cassiers Magazine, New York, M. 1892–date, AIEE; ASME; V. 1, No. 3; V. 5, three numbers; V. 6, No. 31; V. 7; V. 12–date, AIME.

Castings, Cleveland, M. 1907–date, AIME; ASME.

Cement Age, New York, M. 1905–date, ASME.

Central Station (The), New York, M. 1902–date, AIEE.

Centralblatt für Accumulatoren Elementen-und Accumobilen-kunde, Berlin, 1902–date, AIEE.

Chemical and Metallurgical Society of South Africa, Johannesburg. Journal, 1902, AIEE; 1898–date, AIME.

———. Proceedings, Irreg. 1894–date, AIME.

Chemical Engineer, Philadelphia-Chicago, M. 1907–date, AIME.

Chemical News and Journal of Physical Science, London, W. 11–26, 29–52, 55–62, 77–83, 89–date; 1865, AIME.

Chemical Society of London, Journal, M. V. 27—, 1874–date, AIME.

Chemiker-Zeitung, Cöthen, S.-W. 1887–date, AIME.

City and Guilds of London Institute, Central, 1907–date, ASME; AIME.
Civil Engineer and Architects Journal, London, M. 1837–57, AIEE; 1837–1860, ASME.
Coal Trade Journal, New York, W. 1879–date, AIME.
Cold Storage, New York, M. 1902–date, ASME.
——— London, M. 1902–date, ASME.
Cold Storage and Ice Association, London, 1905-date, ASME.
Colliery Guardian, London, W. 1879–date, AIME.
Colorado—State School of Mines, Golden. Bulletin, Q?, 1900–date, AIME.
Colorado Scientific Society, Denver. Proceedings, Irreg. 1886–date, AIME.
Comité des Forges de France, Paris. Annuaire, 1904–date, AIME.
———. Bulletin, 1894–date, AIME.
Compressed Air, New York, M. Current Year, AIEE; 1896–date, ASME.
Connecticut—Geological and Natural History Survey, Hartford. Publications, 1903–date, AIME.
Conservatoire des Arts et Métiers, Paris. Annales, Ser. 2, V. 1–10; Ser. 3, V. 1–4. 1891–1902, AIEE; 1861–1902. ASME; 1889–1902, AIME.
Cordage Trade Journal, New York, B.-M. 1892–date, ASME.
Cuerpo Ingenieros de Minas del Peru, Lima. Boletin, 1902–date, AIME.
Deutsche Chemische Gesellschaft, Berlin. Berichte, M. 1880–date, AIME.
Digest of Physical Tests and Laboratory Practice, Philadelphia, Q. 1896–1897, AIEE; 1896–1898 (except V. 1, No. 4; V. 2; V. 3, Nos. 2-4), AIME.
Dingler's Polytechnisches Journal, Stuttgart, W. 1—, 1820–1901, AIEE; 1891–1897, 1899–date, ASME; 1835–1899, AIME.
l'Echo des Mines, Paris, S.-W. Current Numbers, AIME.
l'Eclairage Electrique, W. 1894–date, AIEE.
École de Génie Maritime, Paris, 1884–1890, 1889–1900, ASME.
Edinburgh Geological Society. Transactions, Irreg. 2, 5, 6–date, 1872, AIME.
Eisen Zeitung, Berlin, W. 1904–date, AIME.
Electric Accumulator, London, 1906–date, AIEE.
Electric City, Chicago, M. 1903–date, AIEE.
Electric Traction Weekly, Cleveland, 1907–date, AIEE.
Electric Journal, Pittsburg, M. 1904–date, AIEE.
Electrical Age, New York, M. 1889–date (incomplete), AIEE; 1904–date, ASME.
Electrical Engineer, London, W. 1882–date, AIEE.
Electrical Engineer, New York, W. 1882–1899, AIEE.
Electrical Engineering, Chicago, 3–12, 1894–1897, ASME.
Electrical Review, New York, W. 1882–date, AIEE; 1883–date, ASME. (Vol. 1–8, Review of the Telegraph and Telephone and Electrical Journal.)
Electrical Review, London, W. 1873–date, AIEE; 1883–date, ASME.
Electrical Worker, Washington, M. 1901–date, AIEE.
Electrical Times, London, M. 1893–date, AIEE.
Electrical World and Engineer, New York, W. 1883–date, AIEE; 1895-date, ASME.
Electrician, London, W. 1878–date, AIEE; 1889–'92, AIME.
Electrician's Friend, Tokyo, M. 1904–date, AIEE.
L'Electricien, Revue Internationale de l'Electricité et ses Applications, Paris, W. 1881–date, AIEE.
Electricity and Electrical Engineering, London, W. 1890–date, AIEE.
Electro, Bruxelles, M. 1902–date, AIEE.
Electrochemical and Metallurgical Industry, Philadelphia-New York, M. 1902–date, AIEE; AIME; 1907–date, ASME.

L'Electrochimie; Revue Mensuelle des Sciences et de L'Industrie, M. 1903–date, AIEE. (Continued by Revue d'Electrochimie et d'Electrometallurgie.)
Electrocraft, Detroit, M. 1–date, 1905–date, AIEE.
Electro-chemist and Metallurgist, London, M. 1901–1904, AIEE; AIME.
Elektrische Bahnen und Betriebe, Munich (6 numbers yearly). 1903–date, AIEE.
Elektrochemische Zeitschrift, Berlin, M. 1903–date, AIEE; AIME.
Elektrotechnik und Maschinenbau, Wien, W. 1906-date, AIEE; 1907–date, ASME.
Elektrotechnischer Anzeiger, Berlin, S.-W. 1895–date, AIEE.
Elektrotechnische Zeitschrift, Berlin, W. 1880–date, AIEE; 1885–1887, 1894–date, ASME.
Elektroteknisk Tidsskrift, Kristiania. 1902–date, AIEE.
l'Elettricista, Roma, S.-M. 1–8, 10–date; 1892–date, AIEE.
l'Elettricita, Milano, W. 8–10, 13–17, 21–date; 1889–date, AIEE.
Emerson Monthly, St. Louis. 1906–date, AIEE.
Engineer (The), Chicago, B.-M. 1892–date, ASME. (Formerly Mechanical Engineer.) 43–date; 1906–date, AIEE.
Engineer (The), London, W. 1–18, 23–44, 52–90, 92–date; 1856–date, AIEE; 1–date, 1856, ASME; 40–57, 59–77, 79–date, 1876, AIME.
Engineer and Steam Engineering, Chicago, M. 1906–date, AIEE.
Engineering, London, W. 3–4, 6–8, 10–11, 13–date, 1867–, AIEE; 1866–date, ASME; 1866–date (except V. 1), AIME.
Engineering and Mining Journal, New York, W. 62–63, 66–72, 73–date, AIEE; 1880-date, ASME; 1866–date (V. 1), AIME.
Engineering Association of New South Wales, Sydney. Proceedings, Y. 1887–1896 and 1903, AIEE; 1885–date, ASME; 1886–1896, AIME.
Engineering Association of the South, Nashville. Proceedings, Q. 1902, AIEE; 1898–date, AIME; 11, 12–15, ASME.
———. Transactions, 1902–1905, AIEE; 1890–date, ASME; 9–date, 1898 AIME.
Engineering-Contracting, New York-Chicago, W. 1906–date, AIME; 190 to date, AIEE.
Engineering Index, New York, Y. 1884–date, AIEE; ASME; AIME.
Engineering Magazine, New York, M. 1891–date, AIEE; 1891 (incomplete)–date, ASME; 1891–date, AIME.
Engineering News and American Railway Journal, New York, W. 23–date, 1890–date, AIEE; 1878–1882, 1884–1887 (Jan.–June), 1888–date, ASME; 1875–date (V. 2) (except 3–6 and 10), AIME.
Engineering Record, New York, W. 4–11, 13–15, 19–23 and 25–, 1880–date, ASME; 17, 45–date, AIEE; 19–27, 29–41, 42–date, AIME.
Engineering Review, London, M. 1904–date, AIEE; 1900–date, ASME; 1903–date, AIME.
Engineering Review (formerly Heating and Ventilation), New York, M. 1895–date, ASME.
Engineering Review, Purdue University. 1905–date, ASME.
Engineering Standards, London. Publications Irreg. AIEE.
Engineering World, Chicago, W. 5—, 1907 (merged with Engineering-Contracting, July, 1907), AIEE; 1907, ASME.
Engineers' Club of Philadelphia. Proceedings, Q. 1, 3, 8–, 1879–date, AIEE; 1–, 1880–date, ASME; AIME.
Engineer's Review, Cleveland. 1907–date, ASME.

Engineers' Society of Western Pennsylvania, Pittsburg. Proceedings, M. 1, 5–date, 1890–date, AIEE; 1880, 1889, 1890, 1892–date, ASME; 1882–date, AIME.
English Mechanic and World of Science, London, W. 1–56, 60–64, 67–70, 72–, 1865–date, AIEE; 1903, AIME; 1865–1893, ASME.
Far Eastern Review, Manila, M. 3, No. 9, 1907–date, AIME.
Faraday Society, London. Transactions, Q. 1–date, 1905, AIEE; AIME.
Fer et Aciér, Bruxelles, M. 1—, 1905–date, AIME.
Field Columbian Museum, Chicago. Publications. Geological Series. 1895–date, AIME.
Fire and Water, New York. 1886–date, ASME.
Forestry and Irrigation, Washington, M. 1902–date, AIME.
Fortschritte der Elektrotechnik, Berlin, Q. 1–5, 9–date, AIEE; 1–20, pt. 2. 1887–1907, AIME.
Foundry, Cleveland, M. 1904–date, ASME; V. 23, 1903–date, AIME.
Franklin Institute, Philadelphia. Journal, M. 1—, 1826–date, AIEE; AIME; 1828–date, ASME.
Gas Engine, New York, M. 1903–date, ASME.
Gas Engineers' Magazine, London, M. 1902–date, ASME.
Gasmotorentechnik, Berlin, M. 1907–date, ASME.
Gas News, Newark, M. Nov., 1904–Sept., 1907, AIEE.
Génie Civil, Paris, W. 1893–date (except Jan–June, 1898), ASME.
Geographical Society of Philadelphia. Bulletin, 1901, ASME.
Geological Society of America, Rochester. Bulletin, Irreg. 1—, 1890–date, AIME.
Geological Society of London. Geological Literature Added to Library. 1894–date, AIME.
——. Quarterly Journal. 1—, 1845–date, AIME.
Geological Society of South Africa, Johannesburg. Transactions (3 numbers yearly). 2, pts. 3–11; 3–4, 6–date, AIME.
Georgia—Geological Survey, Atlanta. Bulletin, Irreg. 2–date, AIME.
Germany-Kaiserliche Statistisches Amt. Berlin. Statistisches Jahrbuch. 1892–date, AIME.
Giesserei-Zeitung, Berlin, S.-M. 1904–date, AIME.
Glaser's Annalen für Gewerbe und Bauwesen, Berlin, S.-M. 1890 (July–Dec.), 1891, 1893-date, ASME; 1881–date (V. 8), AIME.
Glower (The), Pittsburg, M. 1907–date, AIEE.
Glückauf, Essen-Ruhr, W. 32–, 1896–date, AIME.
Great Britain—Patent Office, London. Abridgments of Specifications. 1897–date, AIME.
——. Illustrated Official Journal, W. 1899–date, AIEE; 1903–date, AIME.
Gummi Zeitung, Dresden, W. 1907–date, ASME.
Harvard Engineering Journal, Cambridge, Q. 1902–date, AIEE; 1905–date, ASME.
Heating and Ventilating Magazine, New York. 1906–date, ASME.
Horseless Age, New York, W. 1–2, 4–8, 1896–1900, AIEE; 1898–date, ASME.
Ice and Refrigeration, Chicago-New York, M. 1906–date, AIEE; 1891–date, ASME.
Illinois Geological Survey, Urbana. Publications Current, AIME.
Illuminating Engineer, New York. 1906–date, AIEE.
Illuminating Engineering Society, New York. Transactions. 1, Nos. 1–7; 2, Nos. 1–5, 7–8, 1906–07, AIEE.

Imperatorskavo Russkavo Tekhnicheskavo Obshchestva, St. Petersburg. Zapiski, M. 1897–date, AIME.
India Geological Survey, Calcutta. Memoirs, Irreg. 1860–'78, 1901–date, AIME.
——. Records. 1870–73, 1878–79, AIME.
India. Bureau of Mines Inspection. Annual Report. 1902–date, AIME.
India Rubber and Gutta Percha and Electrical Trades Journal, London, M. 1, Nos. 6–12; 2, Nos. 1–8; 1885–86, AIEE.
India Rubber World, New York, M. 1898–date, AIEE.
Indian Electrical, Mechanical and Textile News, Bombay. 1905–date, AIEE.
Indian Engineering, Calcutta, W. 1887, 1895–date, ASME; 1887–date, AIME.
Indian Territory—Mine Inspector, Washington. Annual Report. 1902-date, AIME.
Indiana Geological Survey, Indianapolis. Annual Report. 1869–date, AIME.
L'Industria, Milano, W. 1906–date, ASME.
Industrial Japan, M. 1907–date, AIME.
Industrial Magazine, New York. 1906–date, ASME; Aug., 1906–date, AIEE.
Industrial World, Pittsburg, W. (Continuation of American Manufacturer and Iron World.) 1907–date, AIME.
Industrial World and Iron Worker, Chicago, W. 1883–1896, ASME; 1880–1897, AIME.
l'Industrie Electrique, Paris, S.-M. 1892–date, AIEE.
Industries. *See* Iron.
Industries and Iron. 1895–1899, ASME. (Continuation of Two Periodicals, Iron and Industries.)
de Ingenieur, Gravenhage, W. 1905–date, AIEE; 1903–date, AIME.
Institution of Civil Engineers, London. Proceedings, Q. 9, 19, 1850–date, AIEE; 1837–date, ASME; 4—, 1845–date, AIME.
Institution of Civil Engineers of Ireland, Dublin. Transactions. 13–17, 19, 23–, 1882–86, 1889, 1884–date, ASME.
Institution of Electrical Engineers, London. Journal. 1872–date, AIEE; 1901–date, ASME; 1903–date, AIME.
Institution of Engineers of the River Plate, Buenos Aires. Journal. Current Year, AIEE.
Institution of Engineers and Shipbuilders in Scotland, Glasgow. Transactions, Irreg. 38, 40, 1894-date, AIEE; 1884–date, ASME; 1901–date, AIME.
Institution of Mechanical Engineers, London. Proceeding, Q. 1—, 1847–date, ASME; 1905–date, AIEE; 1879–date, AIME.
Institution of Mining and Metallurgy, London. Transactions, Y. 1—, 1892–date, AIME.
Institution of Mining Engineers, Newcastle-upon-Tyne. Transactions 1—, 1889–date, AIME.
Institution of Naval Architects, London. Transactions, Y. 1860–73, 1875–date, ASME; 1887–89, 1895–date. AIME.
Insurance Engineering, New York, M. 1901-date, ASME.
International Bureau of American Republics, Washington. Bulletin. 1900–01, 1905–date, AIME.
International Fire Prevention Congress, convened in London. Proceedings, 1903, ASME.
International Geological Congress. 1—, AIME (complete).
International Railway Congress, Brussels. Proceedings. (English Edition.) 1–5, 1901, ASME.
——. Bulletin, M. 1907 (Aug.), 1–date, ASME.

Iowa—Geological Survey, Des Moines. Annual Report. 1893–date, AIME.
Iron, London, W. 1884–92, ASME; 1–41, 1873–1893, AIME. (Absorbed by Industries in 1893, and continued as Industries and Iron, 1895–1899.) (*See* Mechanics' Magazine, 1823–1872, for earlier volumes.)
Iron Age, New York, W. Current Year, AIEE; 1888-1891, 1893–date, ASME; 1879–date, AIME.
Iron and Coal Trades Review, London, W. 1884–date, AIME.
Iron and Steel, Chicago, W. 1899–1905. (Merged with Age of Steel, Iron and Machinery World in 1903), ASME.
Iron and Steel Institute, London. Journal, S.-Y. 1869–date (1869–70 are Transactions), AIME; 1873–date, ASME.
Iron and Steel Metallurgist and Metallographist, Boston, M. Complete, 1898–1906. (Merged with Electrochemical Industry in July, 1906), AIME.
Iron and Steel Trades Journal and Mining Engineer, London, W. 1888-date, AIME.
Iron Trade Review, Cleveland. 1896–date, AIME; 1898–date, ASME.
Ironmonger, London, W. 1881–1902, June, 1904–date, AIME.
Italy—Reale Comitato Geologico, Roma. Bollettino, Q. 1901–date, AIME.
Jahrbuch für das Eisenhüttenwesen, Düsseldorf. 1900–date, ASME; AIME.
Jahresbericht über die Leistungen der Chemischen Technologie, S.-Y. 1867–date, AIME.
Japan—Imperial University, Tokyo. Journal of the College of Science, 1–date, 1887–date, AIEE; 1886–1894, AIME.
Jern Kontorets Annaler, Stockholm, Q. 3, 5–11, 14–15, 32, 1819–date, AIME.
——. Bi-hang, 1900–date, AIME.
Johns Hopkins University, Baltimore. Circulars, Irreg. 1902–date, AIEE; 1884–date, AIME.
Journal de Chimie Physique, Geneva, M. 1—, 1903–date, AIEE.
Journal de l'Electrolyse, Paris. 13, 1904–date, AIEE.
Journal de Physique Theorique et Appliquée, Paris, M. 1872–date, AIEE.
Journal des Mines, 1–38, 1795–1815 (continued by Annales des Mines), AIME.
Journal of Electricity, Power and Gas, San Francisco, M. 1–16, No. 4 (weekly), 16, No. 5, 1895–date, AIEE; 1900–1906, ASME; 1895–1901, AIME (except Nos. 1–2 of V. 1; No. 5 of V. 3; No. 3 of V. 4; Nos. 2, 4, 6 of V. 6; V. 7, 9–11; Nos. 2–6 of V. 8.)
Journal of Geology, Chicago (8 numbers yearly). 1—, 1893-date, AIME.
Journal of Physical Chemistry, Ithaca, M. 6, 1902–date, AIEE.
Journal of the United States Artillery, B.-M. 1–14, 16, 1892–date, AIEE; 1, 1892–date, AIME; ASME.
Journal Telegraphique, Berne, M. 1–11, 26–, 1869–date, AIEE.
Junior Institution of Engineers, London. Record of Transactions, Y. 1891–date, ASME; 2, 1891–date. AIME.
Kaiserlich Königliche Geologische Reichsanstalt, Wien. Abhandlungen, Irreg. 1852–date (set incomplete), AIME.
———. Jahrbuch, Q. 1850–date, AIME.
———. Verhandlungen. 1867–1876, 1880, 1884–date, AIME.
Kentucky—Geological Survey, Frankfort. Bulletin Current, AIME.
Kentucky—Mines Inspector, Frankfort. Report, 1894–date, AIME.
Königlich Preussische Geologische Landesanstalt und Bergakademie, Berlin. Jahrbuch, Y. 1–, 1880–date, AIME.
Königliche Technische Versuchsanstalt, Berlin. Mittheilungen. 1883–date, AIME; 1887–1890, 1893–date, ASME.

Lake Superior Mining Institute, Ishpeming, 1893–date, AIME.

Lead and Zinc News, Joplin, B.-M. 1903–date, ASME ; AIME.

Light Railway and Tramway Journal, London, M. 6–, 1902–date, AIEE ; 1903–date, ASME.

Light and Power, Newark. 1904–date, AIEE.

Liverpool Engineering Society. Transactions, 13–, 1892–date, AIEE ; 1881–date, ASME ; AIME.

Locomotive Engineering, New York, M. 1888–date, ASME.

London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, 1798–date, AIEE ; 1798–1874, AIME.

Machinery, New York, M. Current Year, AIEE ; 1895–date, ASME ; 1904–date, AIME.

Magazine of Popular Science and Useful Arts, London. 1836–37, AIEE ; ASME.

Manchester Association of Engineers. Irreg. 1890–date, ASME ; 1883–date, AIME.

Manchester Geological and Mining Society. Transactions, 15—, 1880–date, AIME.

Manchester Literary and Philosophical Society. Memoirs and Proceedings (5 numbers yearly), 1–, 1785–date, AIEE.

Manufacturer and Builder, New York, M. 1869–1885, ASME ; 1869–1894 (except 2, 4–11), AIME.

Manufacturer's Record, Baltimore, W. 1907–date, ASME.

Marine Engineering, New York, M. 1897–date, ASME.

Maryland Geological Survey, Baltimore. Publications, 1896–date, AIME.

Master Carbuilder's Association, New York. Report. 1874–date (except 1901), ASME ; 1872–date (except 17, 26–27 and 35), AIME.

Mechanics' Magazine, London. 1823–1872, ASME (in 1872 became "Iron ;" in 1893 combined with "Industries" becoming "Industries and Iron ;" discontinued in 1900) ; 1–29, 31–69, 1823–1858, AIEE ; 1823–1827, AIME.

Mechanical Engineer. 1883–1890, ASME.

Mechanical Engineer, London, W. 1898–date, ASME.

Mechanical World, Manchester, W. 1884–1886, 1891–date, ASME.

Memorial du Génie Maritime, Paris. 1900–date, ASME.

Metal Industry, New York, M. 1902-date, AIME ; 1903–date, AIEE ; 1904–date, ASME.

Metallarbeiter, Wien, W. 1904-date, AIME.

Metallgesellschaft and the Metallurgische Gesellschaft, A.-G. Statistical Compilations of Lead, Copper, Smelter, Tin, Silver, Nickel, Aluminum and Quicksilver, 1890–date, AIME.

Métallurgie, Paris, W. 1902–date, AIME.

Metallurgie, Halle a. S. S. M. 1—, 1904–date, AIME.

Mexico—Ministerio de Fomento. Anales, 1877–1898, AIME.

———. Boletin, 1891–date, AIME.

Michigan—Geological Survey, Lansing. Annual Report, 1901–date, AIME.

Michigan Technic, Ann Arbor, S.-Y. 8, 10, 17–, 1895–date, AIEE ; 1904–date, ASME.

Mineral Industry, New York, Y. 1893–date, AIME.

Mineralogical Society, London. Irreg. 1876–date (except V. 1, No. 3, and V. 4), AIME.

Minerva Jahrbuch der Gelehrten Welt, Strassburg, Y. 1905-date, AIME ; 1904, AIEE.

Mines and Minerals, Scranton, M. Current Year, AIEE ; 1897-date, ASME ; 1885–date, AIME.

Mining and Scientific Press, San Francisco, W. Current Year, AIEE; 1870–date, AIME.
Mining Association and Institute of Cornwall, Camborne. Transactions, Irreg. 1889–1895, AIME.
Mining Engineering, London, M. 1896–date, AIEE.
Mining Institute of Scotland, Hamilton. Transactions (5 numbers yearly), 1879–date, AIME; ASME.
Mining Journal, Railway and Commercial Gazette. London, W. 1872–date, AIME.
Mining Magazine, New York, M. 1904–1906, AIEE; AIME; ASME.
Mining Reporter, Denver, W. 1903–1907 (Changed to Mining Science, Dec., 1907), AIME.
Mining Review and Metallurgist, Chicago, M. 1904–date, AIME.
Mining Science, Denver, W. Dec., 1907–date (Formerly Mining Reporter), AIME.
Mining Society of Nova Scotia, Halifax. Journal, 1892–1895, 1900–1905, ASME; 1893–date (Complete), AIME.
Mining World, Chicago, W. 1905–date, V. 23, ASME; 1896–date, AIME.
Missouri Geological Survey, Jefferson City. Biennial Report. 1891, 1893, 1901–date, AIME.
Mitteilungen der Berliner Elektricitäts-Werke, V. 2, 1906–date, AIEE.
Modern Mexico, New York, M. 1899–date, AIME.
Mois Scientific et Industriel, Paris, M. B.-M. 1904–date, AIME; AIEE.
Montana State Inspector of Mines, Helena. Annual Report, 1890–date, AIME.
Motor, New York, 1907–date, ASME.
Municipal Engineering, New York, M. 1903–date, AIEE.
Municipal Journal and Engineer, New York, M. 1903–date, AIEE.
Mysore (India) Geological Department, Bangalore. Memoirs, 1900–date, AIME.
——. Records, 1897–date, AIME.
——. Report of the Chief Inspector of Mines, 1898–date, AIME.
National Electric Light Association, New York. Bulletin, 1, Nos. 1, 3 and 4, 1907, ASME.
——. Proceedings, 1885–date, AIEE; 1885–1894, ASME.
National Electrical Contractor, Utica, M. 1901–date, AIEE.
National Engineer, New York, M. Current Year, AIEE; 1899–date, ASME.
National Fire Protection Association, Boston. Proceedings, 1897–1904, AIEE.
National Fire Protection Association, Hartford, Q. 1–date, 1907–date, AIEE.
National Geographic Magazine, Washington, M. 10, Nos. 8 and 11; 11; 12 Nos. 1–8; 13, Nos. 1, 5–8 and 10; 14; 15, Nos. 1–4, 6–7, 11–12, 16–date, AIME.
Nature, London, W. 1–3, 11–46, 48, 1870–1893, AIEE; 1–66, 1869–1902, AIME.
Naval Architects and Marine Engineers Society. 1893–date, ASME.
Netherlands, East Indies Hoofdbureau van het Mijnwezen. Batavia. Jaarboek van het Mijnwezen, 1903–date, AIME.
Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde, Stuttgart, 1839–1891, AIME.
New England Cotton Manufacturers' Association, 1890–date, ASME.
New England Water Works Association. Journal, Q. September, 1907–date, ASME.
Newfoundland Geological Survey, St. Johns, 1900–date, AIME.
New York Edison Company, New York. Bulletin. 1906–date, AIME.
New York Railroad Club, New York. Proceedings, 1897–date, ASME.
New York State Museum, Albany. Annual Report, 1903–date, AIME.
——. Bulletin, Irreg. 1888–date, AIME.

New Jersey—Geological Survey, Trenton. Annual Report, 1855–date, AIME.

New South Wales—Geological Survey Branch, Sydney. Mineral Resources. 1898–date, AIME.

———. Records, 1889–date, AIME.

New South Wales—Mines and Agricultural Department. Annual Report. 1892–date, AIME.

New York Academy of Sciences. Annals (3 numbers yearly), 1877–date, AIME.

———. Memoirs, Irreg. 1895, AIME.

New York Public Library. Bulletin, M. V. 1, 1897–date, AIME.

New York—State Geologist, Albany. Report, Y. 11, 12–, 1892–date, AIME.

New Zealand—Mines Department, Wellington. Papers and Reports Relating to Minerals and Mining, 1885–date, AIME.

New Zealand Institute, Wellington. Transactions, Y. 1868–date (except 15–16, 19–30 and 32), AIME.

New Zealand Mines Record, Wellington, V. 7, 1903–date, AIME.

Norsk Teknisk Tidsskrift, Kristiania, W. 1883–1897. (Continued by Teknisk Ugeblad), AIME.

North Carolina—Geological Survey, Raleigh. Publications, Current, AIME.

Northeast Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne. Transactions, 1884–date, ASME.

North of England Institution of Mining and Mechanical Engineers, Newcastle-upon-Tyne. Annual Report. 1895–date, AIME.

———. Transactions, 1852–date (complete), AIME; 1880–date, ASME.

North Staffordshire Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne. Transactions, 1, 3–4, 13, pts. 1–5, 1879–1895, AIME.

Norway—Statistiske Centralbureau, Kristiania. Statistisk Aarbog for Kongeriget Norge. 1897–date, AIME.

Nova Scotian Institute of Science, Halifax, 1894–date, AIEE; 1875–date, AIME; 1886–date, ASME.

Nova Scotia—Department of Mines, Halifax. Annual Report, 1862–date, AIME.

Nuovo Cimento, Pisa, M. 1855–date, AIEE.

Oesterreichischer Ingenieur und Architekten Verein, Wien. Zeitschrift, W. 1849–date, AIEE; 1849–1903, 1–53, AIME.

Oesterreichisches Patentblatt, Wien, S.-M. 1906–date, AIEE.

Oesterreichish-Ungarische Montan Und Metallindustrie Zeitung und Rundschau der Maschinenindustrie, Wien, W. 37, 1903–date, AIME.

Oesterreichische Zeitschrift für Berg-und Hüttenwesen, Wien, W. 27–date, 1872–date, AIME.

Ohio—Geological Survey, Columbus. Bulletin. 1903–date, AIME.

Ohio—Inspector of Mines, Columbus. Annual Report. 3–4, 7–9, 11–18, 21–date, 1876–date, AIME.

Oklahoma—Department of Geology and Natural History, Guthrie. Biennial Report. 1901, AIME.

Ontario—Bureau of Mines, Toronto. Report. 1831–date, AIME.

Operator, New York, B.-W. 1874–1885, AIEE.

Ores and Metals, Denver, S.-W. 13–16, 1904–1907. (Merged with Mining Reporter as Mining Science, Dec., 1907), AIME.

Page's Magazine, London, M.-W. 1902–date, AIME; ASME.

Pennsylvania—Department of Internal Affairs, Harrisburg. Annual Report. 1880–date, AIME.

Pennsylvania—Inspector of Mines, Harrisburg. Report. 1870–date, AIME.

Philadelphia Electric Co. Bulletin, Q. 1906–date, AIEE.

Philippine Islands—Mining Bureau. Annual Report. 5–date, AIME.
——— Bulletin; 1902–date, AIME.
Philippine Journal of Science, M. 2, Nos. 1–4, ASME; 1906–date, AIME.
Philosophical Society of Washington. Bulletin, 14, 1900–1903, AIEE; 1–12, 1871–1892, AIME.
Physical Society of London. Proceedings (3 numbers yearly). 1876–date, AIEE.
Physical Review, New York (10 numbers yearly). 1893–date, AIEE.
Physikalische Zeitschrift, Leipzig, S.-M. 3–date, 1902–date, AIEE.
Polytechnic, Troy, M. 1901–date, ASME.
Popular Science Monthly, New York, 1–57, 60–date, 1872–date, AIEE; 1–9, 10, No. 56; 15, Nos. 86–88; 16, Nos. 93, 95 and 96; 17, No. 97; 18, No. 103; 22, Nos. 129, 130, 132; V. 23–54; 55, Nos. 1–2; 57, Nos. 3–6; 58; 59, Nos. 1–5; 60–61; 62, Nos. 1–2; 69, Nos. 3, 5, 6; 70. 1872–date, AIME.
Portugal—Commissaõ do Servico Geologico, Lisboa. Communicacoes. Irreg. 1883–date, AIME.
Power, New York, M. Current Year, AIEE; 1886–date, ASME.
Power's Central Station Directory and Buyer's Manual, New York, Q. 9, No. 4; 10, Nos. 2–4; 11, Nos. 1–4; 1901, AIEE.
Practical Engineer, London, W. 1887–1890, 1893–date, ASME; 1887–1889, AIME.
Practical Mechanic's Journal, Glasgow, 1848–1855, AIEE; 1853–1855, AIME; 1841–1865, ASME.
Practical Mechanic's Journal, London, 1848–1870, ASME.
Progressive Age, New York, S.-M. 1897–date, AIEE; 1898–1901, 1903–date, ASME.
Quarry, London, M. 12–date, 1907–date, AIME.
Quarterly Journal of Science, London, 1–12, 14–22, 1817–1827, AIEE; 4–10, 1867–1873, AIME.
Queen's Quarterly, Kingston, 1900–date, AIME.
Queensland—Government Mining Journal, Brisbane, M. 5–date, 1904–date, AIME.
———. Secretary for Mines, Brisbane. Annual Report. 1900–date, AIME.
———. Geological Survey. Publications, AIME.
Railroad and Engineering Journal, New York, 61–66, 1887–1892. (For later volumes *see* American Engineer and Railroad Journal), ASME.
Railroad Gazette, New York, W. 16–31, 33–date, 1884, AIEE; 1873–1875, 1877–1884, 1888–date, ASME; 1880–1899, AIME.
Railway Age, Chicago, M. 1906–date, AIEE; 1894–date, ASME.
Railway and Engineering Review, Chicago, W. Current Year, AIEE; 1896–date, ASME; 1880–date, AIME.
Railway Gazette, London, W. 1907–date, ASME.
Railway Machinery, Current numbers only, ASME.
Railway Master Mechanic, Chicago, M. 1893–date, ASME.
Railway Reporter, Pittsburgh, M. 1880–1884, AIME. (No more published.)
Railway World, Philadelphia, W. 1880–1895, AIME.
Rassegna Mineraria delle Industria Chimica, Torino (36 numbers yearly), 1897–date, AIME.
Repertorium der technichen Journal Literatur, Berlin, Y. 1856–1879, AIEE; 1823–date, AIME.
Repertory of Patent Inventions, London, M. 1794–1862, AIEE.
Revista de Obras Publicas, Madrid, W. 1902–date, AIEE.
Revista del Ministerio de Obras Publicas y Fomento, Bogota, M. 1904–date, AIME.

Revista Minera Métalurgica y de Ingenieria, Madrid, W. 1903-date, AIME.
Revista Technologico Industrial, Barcelona, M. 1889-date. AIME.
Revue Électrique, Paris, S.-M. 1904–date, AIEE.
Revue d'Electrochimie et d'Electrométallurgie, Paris, M. 1907–date, AIME; AIEE. (Continuation of l'Electrochimie.)
Revue de l'Ingenieur et Index Technique, Bruxelles, M. 1903–date, AIEE; 1—, 1903–date, AIME.
Revue de Mécanique, Paris, M. 1901-date, ASME; 1897–date, AIME.
Revue Générale des Chemins de fer et des Tramways, Paris, M. 1894–date, ASME.
Revue Générale des Sciences Pures et Appliquées, Paris. 1902–date, AIEE.
Revue Minéralurgique, Paris, M. 1903–date, AIME.
Revue Technique, Paris, B.-M. 1904–1905, AIME.
Revue Universelle des Mines et de la Metallurgie, Liége, M. Ser. 2, V. 5, end of series; Ser. 3, V. 1, 3–8, 10, 12-14, 16–, 1879–date, AIME.
Rhodesia Chamber of Mines, Bulawayo. Report. 1901–date, AIME.
Rochester Academy of Science. Proceedings, Irreg. 1891–date, AIME.
Rock Products, Chicago, 1907–date, ASME.
Rose Technic, Terre Haute, M. 1901–date, AIEE.
Royal Astronomical Society of London. Monthly notices, 1875–1898, AIEE.
Royal Geological Society of Cornwall, Penzance. Irreg. 1818–1871, 1905–date, AIME.
Royal Institution of Great Britain, London. Notices of the Proceedings, 1–13, 1854–1893, AIEE.
Royal Observatory, Greenwich. Results of the Magnetical and Meteorological Observations, 1882–1897, AIEE.
Royal Society of Edinburgh. Proceedings, Q. 1879, 1902–date, AIEE.
Royal Society of London. Catalogue of Scientific Papers. 1867–1902, AIEE; AIME.
———. Philosophical Transactions. 1—, 1665–date, AIEE; 1751-1877, AIME.
———. Proceedings. 1—, 1800–date, AIEE.
Royal Society of New South Wales, Sydney. Journal and Proceedings. 9–, 1875–date, AIME; 1876–date, ASME; 1893-1899, AIEE.
Royal Society of Victoria, Melbourne. Proceedings. 16, Pt. 1–date, 1908–date, AIME.
Russia—Comité Géologique, St. Petersburg. Bulletin. 1882–date, AIME.
———. Memoirs. 1883–date, AIME.
Sächischer Dampfkessel Revisions Verein, Chemnitz. 1889, 1890, 1892, 1894–1897, 1900–date, ASME.
Sammlung Elektrotechnischer Vortrage, Stuttgart. 1899–date, AIEE.
Saxony—Königliches Finanzministeriums. Jahrbuch für das Berg und Hüttenwesen im Königliche Sachsen. 1877–date, AIME.
School of Mines Quarterly, New York. 1903–date, AIEE; 1881–1883, 1885–date, ASME; 1—, 1880–date, AIME.
Schweizerische Elektrotechnische Zeitschrift, Zurich, Y. 1904–date, AIEE.
Science, New York, W. 1–9, New Ser. 7–8, 14–date. AIEE; 1–date (complete), AIME.
Science Abstracts, London, M. 1—, 1898–date, AIEE; AIME; 1903–date, ASME.
Scientific American, New York, W. 1–57, 60–76, 78–date, 1859–date, AIEE; 1841-1855, 1859–date, ASME.
———. Supplement, 1-12, 14–24, 28, 1876–89, AIEE; 1876–date, ASME.
Seismological Journal of Japan. 1893–1894, AIME.
Seismological Society of Japan, Yokohoma. Transactions. 1880–1892, AIME.

Sibley Journal of Engineering, Ithaca, M. 1896–date, AIEE; 1899–1900, AIME; 1895–date, ASME.
Smithsonian Institution, Washington. Annual Report. 1—, 1847–date, AIME; 1886–date, ASME.
——. Bureau of Ethnology. Annual Report. 1881–1894, AIME,
——. U. S. National Museum. Annual Report. 1—, 1886–date, AIME.
——. ——. Bulletin. 1876–date, AIME.
——. ——. Contributions from the U. S. National Herbarium. 1905–date, AIME.
——. ——. Proceedings. 1878–date, AIME.
Sociedad Cientifica "Antonio Alzate," Mexico. Memorias y Revista. 1887–date, AIME.
Sociedad Nacional de Mineria, Santiago de Chile, Boletin. M. 1891–date, AIME.
Societa Toscana di Scienze Naturali, Pisa. Atti, Memorie, Y. 1878–date, AIME.
——. Atti, Processi Verbali. 1881–date, AIME.
Société Belge d'Electriciens, Bruxelles. Bulletin (10 numbers a year), 1884–date, AIEE.
Société d'Encouragement pour l'Industrie Nationale, Paris. Bulletin, M. 1802–date, AIME; 1880–date, ASME.
Société de l'Industrie Minérale, Saint Étienne, M. Bulletin. 1879–date, AIME.
——. Compte rendu, 1879–date, AIME.
Société des Ingenieurs Civils de France Paris. Annuaire. 1889–date, AIME.
——. Mémoirs et Compte Rendu. 1895–date, AIEE; 1879–date, AIME; 1880–date, ASME. (All incomplete.)
Société Française de Physique, Paris. Bulletin des Séances. 1900–date, AIEE.
Société Géologique de Belgique, Liége, Annales. Q. 1902–date, AIME.
Société Géologique de France, Paris, Bulletin. M. 1830–date, AIME. (Complete.)
——. Mémoires. Ser. 1–2, 1833–1873, AIME.
Société Géologique du Nord, Lille. Annales. 8—, 1882, 1903–date, AIME.
Société Industrielle de Mulhouse. Bulletin. 1902–date, ASME.
Société Internationale des Electriciens, Paris, M. Bulletin. 1884–date, AIEE.
Society for the Promotion of Engineering Education. Proceedings, Irreg. 1–7, 9–14. 1893–1907, AIME; 1893–1901, 1906, ASME; 5–7, 11–12, 1898–1904, AIEE.
Society of Arts, London. Journal, W. 1–11, 25–31, 33—, 1852–date, AIEE; 28, 31, 33–date, 1883–date, AIME; 1901–date, ASME.
Society of Chemical Industry, Manchester, London. Journal, S.-M. 1—, 1882–date, AIEE; 9, 12–16, 18–date, 1890–date, AIME.
Society of Engineers, London; Transactions, Y. 1—, 1861–date, AIME; 1863, 1868, 1870, 1884, 1881, 1886, 1890, ASME.
Society of Mechanical Engineers, Tokio. Journal. 1897–1904, ASME.
Sound Waves, Chicago, M. 1903–date, AIEE.
South African Association of Engineers and Architects, Johannesburg. Proceedings, Irreg. 3—, 1895–date (?), AIME.
South African Engineering, Johannesburg. 1905–date, AIME.
South African Mines, Commerce and Industry, Johannesburg, W. 1904–date, AIME.
South Dakota—State School of Mines, Vermillion. Bulletin, No. 5–date, 1902–date, AIME.
South Staffordshire Institute of Iron and Steel Workers. 1887–1905, ASME.
Southwestern Electrician, Texas, M. 1905–date, AIEE.

Staffordshire Iron and Steel Institute, Brierley Hill. Proceedings, Irreg. 6–date, 1892–date, AIME.

Stahl und Eisen, Düsseldorf, S.-M. 1881–date, AIME; 1889–date, ASME.

Stationary Engineer, Chicago. 1895–1896, ASME.

Steamship, Leith, M. 1903–date, AIEE.

Stevens Institute Indicator, Hoboken, Q. 15–18, 19, Nos. 1–2, 4; 20–date, 1887–date, AIEE; 20–date, 1903–date, AIME; 1887–date, ASME.

Street Railway Bulletin, Boston. 5–date, 1906–date, AIEE.

Street Railway Journal, New York. M. W. 5, 7–date, 1889–date, AIEE; 1891–date, ASME.

Street Railway Review, Chicago. 5–date, 1895–date, AIEE; 1899–date, ASME. (Present title, Electric Railway Review.)

Tasmania—Secretary for Mines, Hobart. Report, Y. 1901–date, AIME.

———. Progress of the Mineral Industry. 1903–date, AIME.

Technical Index. *See* Revue de l'Ingenieur et Index Technique.

Technical Literature, New York, M. 1907–date, AIEE; ASME; AIME. (Title changed to Engineering Digest, 1908.)

Technical Society of the Pacific Coast, San Francisco. 1–10, 1884–1893 (except Nos. 6 and 9 of V. 9; No. 3 of V. 10), AIME; 2, Jan., Aug. and Nov., 1885; 6, May, 1889, 7–9, 10 (except Nos. 7 and 11); Jan–July, 1895, July–Dec., 1896, ASME. (*See also* Association of Engineering Societies.)

Technical World, Chicago, M. 4-6, of V. 1; V. 2–4, 1904–1906, AIEE; 1—, 1904–date, AIME.

Technics, London, M. 1904–1905, AIME. (No more published.)

Technology Quarterly and Proceedings of the Society of Arts (Mass. Inst. Technology), Boston. 3–date, 1891–date, AIEE; 1888–date, ASME; 1—, 1887–date, AIME.

Technology Review, Boston. 1899–date, ASME.

Teikoku Daigaku, Tokyo. Imperial University of Japan, College of Science Journal, 1886. *See* Japan, Imperial University, College of Science.

Teknisk Tidskrift, Stockholm, W. 1891–date, AIME; current numbers only, ASME.

Teknisk Ugeblad, Kristiania, W. 1883–date, V. 1 (except 16, Nos. 1–5, 27–28, 34; 7, Nos. 27 and 48), AIME; current numbers only, ASME.

Tekniske Forenings Tidskrift, Kobenhaven, M. 1902–date, AIME.

Telegraph Age, New York, S.-M. 1894-date, AIEE.

Telegraph Chronicle, London, S.-M. 19–date, 1902-date, AIEE.

Telegraph Electrical Society, Melbourne. Transactions, Q. 1875–1881, AIEE.

Telephone Magazine, Chicago, M. 1–26, 1893–1905, AIEE; 1893–1905 (V. 1, 2 and 9 incomplete), AIME.

Telephone News, Philadelphia, S.-M. 1905–date, AIEE.

Telephone World, Lafayette, M. 1907, AIEE.

Telephony, Chicago. 4–date, 1903–date, AIEE.

Textile World Record, Boston. 1895–1898, 1902–date, ASME.

Tonindustrie Zeitung, Berlin, W. V. 29, Nos. 115, 124, 128–134, 138–140; V. 31, Nos. 97, 98, 102–date, 1905, 1907–date, AIME.

Traction and Transmission, London, M. 1–10, 1901–1906. (No more published?), AIEE; ASME.

Tramway and Railway World, London, M. 11, 1902–date, AIEE.

Transmitter, Sydney, M. 12–date, 1902–date, AIEE.

Transvaal—Commissioner of Mines. Yearly Report of the Government Mining Engineer. 1902–date, AIME.

Transvaal Chamber of Mines. Report. 1900, AIME.

l'Union des Charbonnages, Liége. Bulletin. 11, 1879–date, AIME (except pts. 1–4 and V. 15).

U. S. Association of Charcoal Iron Workers, Philadelphia. Journal, B.-M. 1-9, pt. 1, 1880–1891, AIME; 1880–1888, ASME.

U. S. Department of Agriculture, Washington. Annual Report. 1862, 1868, 1870–1871, 1875 and 1878, AIME; 1867, 1876, 1877, 1881, 1882, 1883–1884, 1886, ASME.

U. S. Bureau of Standards, Washington. Bulletin. 1–date, 1904–date, AIEE; ASME; AIME.

——. Annual Report of the Director. 1902–date, ASME; AIME.

U. S. Census Bureau. Bulletin Nos. 20–date, 1905–date, AIME.

——. Reports and Abstracts of the 10th, 11th and 12th, ASME; Reports and Abstracts of the 9th, 10th, 11th and complete set of 12th, and Special Reports, AIME.

U. S. Civil Service Commission. Annual Report. 9, 11, 17, 1893–1901, AIME; 1896–1900, ASME.

U. S. Coast and Geodetic Survey. Annual Report. 1851-date (except 1876, 1896, 1898), AIME; 1852, 1856, 1894, ASME.

U. S. Congress. Official Congressional Directory. 1892, 1904, AIME; 1904, AIEE.

U. S. Education Bureau, Report of the Commissioner. 1877, 1884, ASME; 1872, 1873, 1876, 1878, 1879, 1882–1890, 1893–1894, 1895–date, AIME.

U. S. Engineers Corps. Annual Report of the Chief Engineer. 1863–1869, 1871, 1876, 1877, 1879–1886, 1888–date, AIME; 1867, 1875, 1876, 1878, 1879, 1886, 1889–1900, ASME.

U. S. Foreign Commerce Bureau. Consular Reports. 1903-date, AIME.

U. S. Forestry Bureau. Bulletin. 1888–date, AIME.

——. Circulars. 1896–date, AIME.

U. S. Geographical and Geological Survey of the Rocky Mountain Region. Reports, 1877–1879, AIME.

U. S. Geographical Surveys West of the 100th Meridian. Report. 1875–1880, AIME.

U. S. Geological and Geographical Survey of the Territories. Annual Report. 1867–1877, AIME.

——. Bulletin. 1874–1881, AIME.

U. S. Geological Exploration of the 40th Parallel. Report. 1870-1880, AIME.

U. S. Geological Survey. Annual Report. 1-, 1880–date, AIME; 1880–1906, ASME.

——. Bulletin. 1-, 1884–date, AIME; Nos. 1-290, ASME.

——. Geologic Folios, Nos. 1–date, AIME; Nos. 1-290, ASME.

——. Mineral Resources of the United States. 1882-date, AIME; 1883–1890, ASME.

——. Monographs. 1-, 1890–date, AIME; 1–40, ASME.

——. Professional Papers. 1–date, AIME; 1-40, ASME.

——. Water Supply and Irrigation Papers, Nos. 2–date, 1897–date, AIME.

——. Topographic Maps. Incomplete, AIME; folios 1-3, ASME.

——. Reclamation Service. Annual Report, 3, 6–date, AIME.

U. S. International Bureau of American Republics. Bulletin. 1905–date, AIME.

U. S. Interstate Commerce Commission. Annual Report. 1896–date, ASME; 1902, 1904, 1905, AIME.

——. Annual Report of the Statistics of Railways. 1902, ASME; 1889, 1890, 1904, AIME.

U. S. Library of Congress. Report of the Librarian, AIEE ; 1903–date, AIME.

———. Publications, AIEE ; 1903–date, AIME.

U. S. Light House Board. Annual Report. 1874, 1875, 1883, 1884, 1886, 1888, 1899–date, ASME.

U. S. Military Service Institution. Journal. 2–8, 28–date, 1881, AIME ; 1880–1886, ASME.

U. S. Mining Statistics, Commissioner of. Statistics of Mines and Mining West of the Rocky Mountains. 1870–1877, AIME.

U. S. Mint Bureau. Annual Report of the Director. 1873, 1875–date, AIME.

———. Report upon the Production of Precious Metals in the U. S., 1880–date, AIME.

U. S. Naval Observatory. Astronomical Observations. 1847, 1849–1850, 1851–1852, AIME; 1851, 1852, 1873, 1878, ASME.

———. Publications of the U. S. Naval Observatory. 1875–date, ASME.

———. Reports. 1889–date, ASME.

U. S. Ordnance Department. 1862, 1864, 1873, 1876–1880, 1882, 1888–1889, 1892–date, AIME ; 1881–1893, ASME.

———. Report of the Test of Metals and Other Materials. 1882–date, AIME ; 1880–date, ASME.

U. S. Patent Office. Annnal Report. 1847–68, 1890–date, AIME ; 1847, 1848, 1849, 1851–1870, ASME.

———. Official Gazette. 1890–date, AIME ; 1898–date, AIEE ; complete set, 1872–date, ASME.

U. S. Signal Office. Annual Report of the Chief Signal Officer. 1872, AIME ; 1885, pts. 1–2, ASME ; Publications, 1907, AIEE.

———. Professional Papers of the Signal Service. Nos. 1–2, 6, 8, pt. 1, 9, 11–12, 15–16, 18, 1881–1885, AIME.

U. S. Statistics Bureau. Foreign Commerce and Navigation of the U. S. 1896, 1902–date, AIME.

———. Monthly Summary of Commerce and Finance, Dec. 1903–date, AIME.

———. Statistical Abstract, Y. 1889, 1897–date, AIME.

U. S. Steam Engineering, Bureau of. Annual Report. 1871–1872, 1874–1878, 1881–date, AIEE ; 1881, 1890–date, AIME ; 1871–72, 1874, 1878, 1881–date, ASME.

U. S. Naval Institute, Annapolis. Proceedings, Q. 1874–1876, 1879–date, ASME ; 1878–date, V. 5, AIME.

Universal Electrical Directory, London. 1883–85, 1887–89, 1894–97, 1898–99, 1901–date, AIEE.

University Chronicle, Berkeley, B.-M. 1–date, 1898–date, AIME.

University of California, Department of Geology. Bulletin, Irreg. 1–date, 1893–date, AIME.

University of Tennessee Record, Knoxville, B.-M. 1, 8–9, 11, 13, 14. V. 4, Nos. 2–3, 6–9, 1898–date, AIEE.

University of Wisconsin, Madison. Bulletin. Engineering Series. 1894–1900, AIME.

———. ———. Science Series. 1892–date, AIME.

University of Upsala, Geological Institution. Bulletin, Irreg. 1894–date, AIME.

University of Wyoming School of Mines, Laramie. Bulletin, Irreg. 1893, 1897, 1899–date, AIME.

Utah—Coal Mine Inspector, Salt Lake City. Reports. 1901, AIME.

Van Nostrand's Eclectic and Engineering Magazine, New York, M. 1869–1886, ASME ; 1-11, 21–35, 1869–1886, AIME. (Merged with the American Railroad Journal, in 1887, as the Railroad and Engineering Journal.)

Verein Deutscher Ingenieur, Berlin. Zeitschrift, W. 44–date, 1900–date, AIEE; 1878–date, AIME; 1870 date, ASME.

Verein für die Bergbaulichen Interessen im Oberbergamts Bezirk Dortmund. Jahresbericht. 1895–date, AIME.

Vermont—State Geologist. Reports, Irreg. AIME.

Victoria Chamber of Mines, Melbourne. Monthly Report. 1904–date, AIME.

Victoria—Geological Survey, Melbourne. Bulletin. 1903, AIME.

Victoria—Department of Mines and Water Supply, Melbourne. The Goldfields of Victoria, Monthly Returns. 1899–date, AIME.

Virginia—Geological Survey, Richmond. Bulletin, Irreg. 1905, AIME.

Washington—Geological Survey, Olympia-Tacoma. 1902–date, (?), AIME.

Washington—State Inspector of Coal Mines, Seattle. Report. 1901–, AIME.

West of Scotland Iron and Steel Institute, Glasgow. Journal. 1894–date, AIME; V. 4, 1896–date, ASME.

West Virginia—Geological Survey, Morgantown. Bulletin, Irreg. 1901–date, AIME.

West Virginia—Mine Inspector. Annual Report on the Coal Mines, Charleston. 1883–date, AIME.

Western Australia—Geological Survey. Annual Progress Report. 1903–date, AIME.

——. Bulletin. Irreg. 1—, 1898–date, AIME.

——. Mines Department, Perth. Gold Mining Statistics. 1896–1899, 1900–date, AIME.

Western Electrician. 1904–date, ASME; 1887–date, AIEE.

Western Railway Club, Chicago. Official Proceedings. 1902–date, AIEE; 1890–date (early volumes imperfect), ASME; 1897–date, AIME.

Western Society of Engineers, Chicago. Journal, B.-M. 1896–date, AIEE; ASME; 1898–date, AIME.

Western Telephone Journal, Vinton. 1907, AIEE.

Wisconsin—Geological and Natural History Survey. Bulletin. 1898–date, AIME.

Woodcraft, Cleveland, M. 1906–date, ASME.

Worcester Polytechnic Institute Journal. 1897–date, ASME.

World Almanac and Encyclopedia, Y. 1900–date, AIME; Current, ASME.

World's Progress, Washington. 1–date, 1905–date, AIEE.

Yale Scientific Monthly, New Haven. 9–, 1903–date, AIEE.

Zeitschrift der Deutscher Ingenieur Vereines. *See* Verein Deutscher Ingenieur.

Zeitschrift der Oesterreichische Ingenieur und Architekten Vereins. *See* Oesterreichischer Ingenieur u. Architekten Vereins.

Zeitschrift für Anorganische Chemie, Irreg. 1–, 1892–date, AIME.

Zeitschrift für Angewandte Chemie, W. 12–14, 18–date, 1900–1902, 1905–date, AIME.

Zeltschrift für Bergrecht, Q. 14–15, 42–date, 1873–1874, 1901–date, AIME.

Zeitschrift für Beleuchtungwesen Heiz und Luftungs-Tecknik, Berlin. 1902–date, AIEE.

Zeitschrift für das Berg-Hütten und Salinenwesen im Preussische Staate, Q. 1–date, 1854–date, AIME.

Zeitschrift für Dampfkessel und Maschinenbetriebe. 1893–date, ASME.

Zeitschrift für Elektrochemie, W. 9–date, 1903–date, AIEE; 1—, 1894–date, AIME.

Zeitschrift für Elektrotechnik, Wien, W. 7–17, 18–23, 1889–1905. (Changed to Elektrotechnik und Maschinenbau), AIEE.

Zeitschrift für Elektrotechnik und Maschinenbau, Potsdam, S.-M. 1903–date, AIEE.

Zeitschrift für das Gesamte Turbinenwesen, Munich-Berlin. 1907–date, ASME.

Zeitschrift für Instrumentenkunde, Berlin. (Official Organ of the Physikalisch-Technisch Versuchsanstalt zu Berlin.) 1901–date (?), AIEE.

Zeitschrift für Kleinbahnen, Berlin, M. 9–date, 1902–date, AIEE.

Zeitschrift für Praktische Geologie, Berlin, M. 1—, 1893–date, AIME.

Zeitschrift für Architektur und Ingenieurwesen. *See* Architekten-und Ingenieur-Vereins zu Hannover.

Zpravy Spolku Architektuv a Inzenyru v Kralovstvi Geskem, Prague. 1904, current numbers only, ASME.

MEMBERSHIP.

The following list comprises the names of those persons elected as members or associates, who accepted election during November and December, 1907:

MEMBERS.

George S. Backus,	Smuggler, Colo.
Sydney H. Ball,	Luebo, Congo Free State, W. Africa.
Albert B. Bartlett,	Cheyenne, Wyo.
Astolfo Bartoccini,	Monterey, N. L., Mex.
Mowry Bates,	New York, N. Y.
John L. W. Birkinbine,	Mexico City, Mex.
Francis C. Bowman,	Smuggler, Colo.
John T. Brown, Jr.,	Pittsburg, Pa.
John R. Chamberlain,	New York, N. Y.
Frederick H. Clark,	Guanajuato, Mex.
Glenville A. Collins,	Seattle, Wash.
George M. Colvocoresses,	New York, N. Y.
Frederick S. Cook,	Joplin, Mo.
Edward T. Corkill,	Toronto, Can.
Frederick Corkill,	Tonopah, Nev.
Fritz Cremer,	South Chicago, Ill.
Frederick G. Crist,	San Dimas, Durango, Mex.
Timothy I. Crowley,	Hornitos, Cal.
Bracey Curtis,	Nogales, Ariz.
Thomas F. Donnelly,	El Oro, Mex.
Albert H. Donnewald,	St. Louis, Mo.
Francis V. Drake,	Bishop, Cal.
Elmer W. Durfee,	Congress Junction, Ariz.
William F. Dutton,	New York, N. Y.
William H. Emmons,	Washington, D. C.
Frederick B. Flinn,	East Orange, N. J.
Isaac P. Fraizer,	Rolla, Mo.
Gay N. Freeman,	Thermopolis, Wyo.
Fortunato P. Gamba,	Pasto, Colombia, S. Am.
George T. Gambrill, Jr.,	Baltimore, Md.
Russell T. Gard,	New Haven, Conn.
Herbert W. Gartrell,	Bisbee, Ariz.
Charles E. Gilman,	San Francisco, Cal.
Lyman F. Gordon,	Worcester, Mass.
Clyde T. Griswold,	Colorado Springs, Colo.
Herbert C. Hale,	Cleveland, Ohio.
John S. Hamman,	Rhyolite, Nev.
Carle R. Hayward,	Quincy, Mass.
Joseph H. Hedges,	Guanacevi, Durango, Mex.

A. Roy Heise,	Wadsworth, Nev.
Enoch Henderson,	Matchwood, Mich.
Herbert T. Herr,	Denver, Colo.
Frank L. Hess,	Washington, D. C.
Hiram W. Hixon,	Victoria Mine, Ontario, Can.
Wilson W. Hughes,	Guanajuato, Mex.
Henry M. Huxley,	New York, N. Y.
Dion L. Johnson,	Duquesne, Pa.
Berthold Kapelowitz,	Germiston, Transvaal, S. Africa.
Cyril W. Knight,	Toronto, Can.
Wilbur G. Laird,	New York, N. Y.
Frederick G. Lasier,	Birmingham, Mich.
James Lea,	Johannesburg, Transvaal, S. Africa.
Charles B. Lessner,	Carril, Spain.
Frank C. Loring,	Toronto, Can.
John E. Masters,	Silver City, Idaho.
John A. Mitchell,	Haileybury, Ontario, Can.
William S. Mitchell,	Haileybury, Ontario, Can.
Francisco Narvaez,	Pachuca, Hidalgo, Mex.
Frederick S. Pheby,	Ely, Nev.
Cecil W. Pocock,	Bayonne, N. J.
Edmund A. Prentis, Jr.,	New York, N. Y.
Lorin T. Putman,	Zeigler, Ill.
Brent N. Rickard,	Mapimi, Durango, Mex.
Fred E. Rightor,	Hymera, Ind.
Alexander J. M. Ross,	Blair, Nev.
Oswald N. Scott,	Toronto, Can.
Stewart K. Smith,	Terre Haute, Ind.
Morton Stevens,	Philadelphia, Pa.
Robert W. Thomson,	Toronto, Can.
William H. Tolman,	New York, N. Y.
Julius H. Warner,	Haileybury, Ontario, Can.
Wilfred F. Wheeler,	Urbana, Ill.
Philip R. Whitman,	Concheno, Chihuahua, Mex.
Francis G. Wickware,	New York, N. Y.
Charles W. Workman,	Jalisco, Mex.

ASSOCIATES.

Glen A. Ricks,	Houghton, Mich.
Alexander H. Smith,	New York, N. Y.

CANDIDATES FOR MEMBERSHIP.

MEMBERS.

William Robert Askwith,	Haileybury, Ontario, Can.
John Ferguson Black,	Sudbury, Ontario, Can.
Willis Smith Caypless,	Denver, Colo.
John Henry Dowe,	London, England.
Erminio Ferraris,	Monteponi, Sardinia.
Heinrich F. Grondijs,	Oruro, Bolivia, S. America.
Roy J. Holden,	Blacksburg, Va.
Frederick Alva Horswill,	Stone Cañon, Cal.
Frederick Jeffrey Horswill,	Oakland, Cal.
George Alexander Howells,	New York, N. Y.
Frederick Henry Jackson,	Indé, Durango, Mex.
Arthur L. Kelley,	Tonopah, Nev.
A. P. Kennedy,	Alexander City, Ala.
Edward F. Kenney,	Johnstown, Pa.
Joseph Richard Lashbrooke,	Berkeley, Cal.
Curtis Mendenhall Lindley,	McGill, Nev.
Philip L. Marston,	Mocorito, Sinaloa, Mex.
John Thomas Mosley,	Stirling, Otago, N. Z.
Frederic Clinton Paine,	Sonoma, Cal.
Robert Streeter Porter,	Stone Cañon, Cal.
Frank W. Pugsley,	Cobalt, Ontario, Can.
Samuel H. Richardson, Jr.,	Republic, Wash.
Hallet R. Robbins,	Albany, N. Y.
Walter E. Segsworth,	Toronto, Can.
Lee Hazen Skeels,	Urique, Chihuahua, Mex.
Lloyd B. Smith,	State College, Pa.
Charles C. Swartz,	South Norwalk, Conn.
James Scott Thompson,	Flat River, Mo.
William James Watson,	Ladysmith, B. C., Can.

ASSOCIATES.

John Murray Clark,	Toronto, Can.
Joseph Brown Elwell,	New York, N. Y.
Desaix Brown Myers,	Philadelphia, Pa.
James Montgomery Raine,	South Bethlehem, Pa.

NECROLOGY.

The deaths of the following members and associates have been reported to the Secretary's office during November and December, 1907:

Date of Election.	Name.	Date of Decease.
1888.	*John Blue,	November 2, 1907.
1882.	*William R. Boggs, Jr.,	November 28, 1907.
1886.	*T. Forster Brown,	October 23, 1907.
1887.	*J. K. Eveleth,	December 6, 1907.
1877.	*B. J. Harrington,	November 29, 1907.
1898.	*Karl Howard,	July —, 1907.
1899.	†Thomas J. Hurley,	December 13, 1907.
1894.	**H. E. Ingram,	September 12, 1907.
1888.	*James F. Jones,	November 7, 1907.
1887.	*Charles A. Molson,	November 26, 1907.
1904.	*Alfred M. Rock,	August 24, 1907.
1879.	*Henry T. Townsend,	September 11, 1907.
1883.	*Lewis Williams,	September —, 1907.

* Member. ** Life Member. † Associate.

CHANGE OF ADDRESS OF MEMBERS.

The changes of address of members received at the Secretary's office during November and December, 1907, together with former changes, published in *Bi-Monthly Bulletin*, No. 14, March, No. 15, May, No. 16, July, No. 17, September and No. 18, November, 1907, have been duly incorporated in the annual list of members corrected to Jan. 1, 1908.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Barnardo, William S. E.,	Surbriton, Surrey, England.
Bellam, Henry L.,	Reno, Nev.
Berry, J. F.,	East Rand, Transvaal, S. Af.
Bradley, Richard J. H.,	15 William St., New York, N. Y.
Bruce, Thomas C.,	Consolidated Bldgs., Johannesburg, S. Af.
Burhans, Harry H.,	Michigan College of Mines, Houghton, Mich.
Dikeman, J. M.,	Rough and Ready, Cal.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Ekberg, Benjamin P.,	199 Main St., Johannesburg, S. Af.
Foster, Floyd J.,	Villaldama, Nuevo Leon, Mexico.
Francis, George G.,	117 St. George's Square, London, W., England.
Hybinette, Victor,	Fredericktown, Mo.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Jones, Edward H.,	Globe, Ariz.
Lukis, E. duB.,	Ica, Peru, S. America.
McCann, Ferdinand,	Los Grados, Guerrero, Mexico.
Merriam, Wallace W.,	Apartado 145, Parral, Chih., Mexico.
Mueller, Henry C.,	General Delivery, San Francisco, Cal.
Reisinger, Paul,	Great Northern Ry. Co., Minot, N. D.
Rilly, Paul de,	San Felipe, Guanajuato, Mexico.
Roberts, Fred C.,	Chrystal Falls, Mich.
Roesler, August,	74 Broadway, New York, N. Y.
Schraubstadter, R. T.,	3215 Hawthorne Blvd., St. Louis, Mo.
Seward, John,	131 Washington St., East Orange, N. J.
Shaw, Clarence L.,	Ely, Nevada.
Thomas, George W.,	Exposed Treasure Mining Co., Mojave, Cal.
Thomas, James A.,	115 New Montgomery St., San Francisco, Cal.
Tonkin, John,	2603 E. Broad St., Richmond, Va.
Watson, Ralph W.,	122 E. S. Temple St., Salt Lake City, Utah.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Biographical Notices, 1907.

THE following paragraphs comprise such information as the Secretary has been able to obtain concerning the members and associates whose deaths have been reported. Further particulars or corrections of errors, and biographical data concerning deceased members or associates not already noticed in this way, are solicited.

[SECRETARY'S NOTE.—All of these notices have been revised, and some of them have been more or less completely prepared, by me. To those which contain more particularly the expression of my personal feeling, my initials have been appended. The labor of preparing or editing these paragraphs has been in many respects both welcome and interesting, on the one hand, and sorrowful, on the other. In going through the list, I have repeatedly felt like one who, visiting the Morgue, suddenly comes upon the pale face of a dear friend, of whose death he was not aware; and, even when this fact was known to me, the work of recording it has brought upon me a flood of recollections, almost preventing the discharge of that official duty.

The list for 1907 seems to me to be peculiarly sad, comprising, as it does, so many sudden deaths by violence or accident, so many veterans, removed too soon, and so many young men whose early departure impoverishes the future, even more than the present. Probably, this feeling on my part is largely due to the circumstance that the increased membership of the Institute necessarily involves an increase of the annual death-list. Probably, also, it is connected with the circumstance that during the first years of the history of the Institute—say from 1871 to 1880—it was joined by men of all ages, and that the death-rate is consequently now above the average which would result from the normal annual addition, principally of young men. And finally, I must admit that, as one of the original members of the Institute, and practically connected with it for nearly thirty-seven years as Acting President, President or Secretary, I am peculiarly impressed and depressed by the successive deaths of those who were my associates in the years of its early struggles and triumphs.

I do not wish to inflict upon my younger colleagues the melancholy reflections of an increasingly lonesome old man. In fact, my prevailing mood concerning the Institute is not at all melancholy, but triumphant and hopeful. If I may be permitted to preach at all, I would enforce, from the texts given below, a moral which many of them declare so forcibly as to preclude the necessity of expository enforcements—namely, the duty of every one of us, old or young, to give to his brethren, *as he goes along*, and without waiting for some future occasion for a comprehensive and monumental contribution to technical literature, the results of his observation and experience. When I look at this list of names, my personal sorrow over many of them is drowned in my professional reflection as to each and all—How much has died with them which they might have left to their succes-

sors, if they had not been too busy, or too modest, or too much inclined to procrastinate a service not peremptorily and immediately required! If I had but one word more to address to my brethren in the Institute, before closing my own lips, I think this would be the word!—R. W. R.]

Peter Townsend Austin was born in 1852, at Clifton, Staten Island, N. Y., and died Dec. 30, 1907, after an illness of several months. Although he did not become a member of the Institute until 1905, and found, during the brief period of health and intellectual activity which intervened between that date and his final illness, no opportunity to contribute to its *Transactions*, the record of his distinguished career as an American representative of scientific progress deserves a place here, as well as in our national history.

During his course at Columbia University, New York, from which he was graduated in 1872 as Bachelor of Philosophy in Chemistry, he won the Torrey prize for the best work in qualitative analysis, and assisted Prof. C. F. Chandler in editing the *American Chemist.* After his graduation, he spent three years at Berlin, Germany, in the laboratory of Prof. Hofmann, who, in 1876, wrote of him: "Mr. Austin combines with a perfectly sound and greatly extended knowledge of physical and chemical science a remarkable experimental skill and dexterity."

Returning in that year to America, he became instructor in chemistry at Dartmouth college, and in 1877 professor of chemistry at Rutgers College, N. J. This position he held for many years, during which he not only achieved a high reputation as an instructor, but also, in connection with the "University extension" work of Rutgers College, delivered in New Jersey towns many useful and entertaining popular lectures on chemistry. During the same period, he was frequently employed as an expert in law suits involving chemical facts and principles, or for the presentation to legislative committees of evidence and argument concerning proposed legislation which affected the interests of large manufacturing industries. He testified as expert chemist in the famous case of the city of Newark against the city of Passaic, which involved the question of the pollution of the Passaic river as a water-supply, and ultimately resulted in securing a new source of supply, for the former city.

In 1893, Prof. Austin became professor of chemistry at the

Polytechnic Institute, Brooklyn, N. Y., where the rapid and successful development of his department bore witness to his scientific knowledge, pedagogic skill and administrative ability. In Brooklyn, as in New Jersey, his fitness for public service was recognized. He served at various times as chemical expert of the Brooklyn Department of City Works, Civil Service Examiner in Chemistry for Brooklyn, president of the chemical department of the Brooklyn Institute of Arts and Sciences, and chairman of a committee of experts, appointed by the Mayor of the then city of Brooklyn, to investigate the perils to human life, connected with the recently introduced electrical "trolley-cars."

In addition to these varied public activities, Prof. Austin made and patented several inventions, and, not long before his death, withdrew from regular work as a teacher, in order to give his time to professional consultations, etc.

Besides the positions and functions mentioned above, and his membership, in sundry collegiate or literary societies, he was at various times chemist of the Richmond county (N. Y.) Board of Health, the Newark Aqueduct Board, the Jersey City Board of Public Works, the New Brunswick and the Newark Board of Health and the N. J. State Board of Agriculture; also, the State Chemist of New Jersey, the President of the New York section of the American Chemical Society, and a member of the American, English, French, German and Russian Chemical Societies, the American Association for the Advancement of Science, the New Jersey State Sanitary Association, the Society of Chemical Industry, etc., etc.

As an author, Prof. Austin contributed to technical literature many articles, which appeared in leading American and foreign journals. In 1893, he published a revised translation of Pinner's *Organic Chemistry*, and in 1891 a volume of *Notes for Chemical Students.* He became a member of the Institute in 1905—too late, as it turned out, to give us directly the benefit of his knowledge and experience.

Carl Wilhelm Bildt died May 5, 1906, at the age of 52 years. He was educated at the Stockholm School of Mines. In 1880 he secured a position at the Washburn & Moen Wire Works in Worcester, Mass., and was chief inspector there for

fifteen years. While in America he invented his celebrated gas-producer. In 1899 he returned to Sweden and was appointed engineer to the Ironmasters' Association. He was elected a member of this Institute in 1886, and of the Iron and Steel Institute in 1899. He contributed to our *Transactions* (xxviii., 166) a paper entitled An Automatic Feed-Device for Gas-Producers.

John Blue was born July 14, 1843, near Glasgow, Scotland. He received a public school education, and four years of private tuition, before he was articled to the firm of Robertson & Co., civil engineers, of Glasgow, with whom he served in that capacity for seven years. After this period of professional training, he spent some time in the coal-mines of Scotland. In 1865 he came to Canada, and entered the employ of the Grand Trunk Railway, with which he continued as an engineer until 1869, when he was appointed superintendent of the East End operations at the Hoosac Tunnel, Mass., a position which he held until the completion of the project in 1875. In that year, Mr. Blue was placed in charge of deepening and widening the Lachine Canal. When this task had been completed, he was engaged for about two years and a half in building a section of the International Railway near Scotstown. His next undertaking was the construction of a section of the Quebec Central Railway. In 1880, he took charge of the mines now owned and operated by the Eustis Mining Co., near Sherbrooke, Quebec; and this position he retained until his death, which was caused, Nov. 2, 1907, by an unfortunate accident for which he was in no way responsible.

Mr. Blue became a member of this Institute in 1888. He was elected to official position in the General Mining Association of Quebec, the Federated Canadian Mining Institute, and the Canadian Mining Institute; and the recognition of his professional eminence thus expressed was heartily shared by his colleagues in the United States.

To this imperfect outline of his career, the following tributes, illustrating his personal character, may be appropriately appended. Mr. W. E. C. Eustis, the President of the American company which he served so long, writes of him:

To those to whom he was best known, and to whom, it may be said, he more immediately belonged, who lived in his society and enjoyed his friendship, his professional character is not that by which he will be most frequently recalled, most deeply lamented, or even most highly admired. He was a remarkable, and, in many respects, a wonderful man. Of a most sensitive and retiring disposition, he shunned publicity; but, despite his innate modesty and almost studied avoidance of public recognition, he had earned a position of widespread prominence and respect such as few men attain. He found ample reward in a whole-souled devotion to the duties of his position, whatever they might happen to be.

A touching tribute to his memory, and an evidence of the mutual regard that existed between him and his people, was given when he was borne to his last resting-place by six of his workmen, who had been employed under his superintendency for periods aggregating about two hundred years.

He was the very model of a captain of industry, a born leader of men,—just, firm, decisive and energetic; inspiring to effort by the example of his own tireless energy; encouraging his men by sharing their hardships, as his tragic death showed that he shared their dangers also. He always manifested an almost paternal interest in their welfare, and dispensed an even-handed justice whenever there were grounds of difference. Like one of old, he was "content to dwell among his people," in a daily touch with their personal and family life, so intimate that their homes may be said to have been only an extension of his own. He was no friend of cant in any form, but his heart overflowed with that charity which is the life-blood of true religion. He died in the service of the company, to the interests of which he had so long and faithfully devoted his great ability; and inexpressibly sad as the manner of his death may seem, there can be no doubt that he himself would have preferred, had it been possible for him to choose, thus to end his earthly life in the active performance of duty.

Prof. Robert H. Richards, of the Massachusetts Institute of Technology, writes as follows:

When Mr. Blue came to the Eustis mines, he found affairs in a very unsatisfactory condition as to the moral atmosphere of the place. There were in the neighborhood drinking-saloons in abundance, but there was no religious influence at all. On Saturday night the "drunks" returning from Sherbrooke practically owned the train, so it was almost impossible for the conductor to collect the fares. Early in his administration, Mr. Blue started church services, securing a minister to attend, in frequent periodical visits, to the spiritual needs of the neighborhood. He succeeded in getting the saloons removed from the neighborhood; and a few years later—in 1888, at the time we held there the Summer School of the Massachusetts Institute of Technology—it was one of the most quiet and orderly mining camps I have ever visited.

Moreover, Mr. Blue used to organize every July (I think it was on "Dominion Day") what he called "The Eustis Picnic." That day was a holiday at the mines; and all hands gathered for a "jollification" on suitable grounds in the vicinity. With the aid of friends and neighbors in Sherbrooke, Mr. Blue maintained the innocent and wholesome enjoyment of the occasion through prize-competitions in games and contests of all kinds, so that the annual "Eustis Picnic" was anticipated with pleasure and remembered with satisfaction by the miners and their families. There can be no doubt that this evidence of his sympathy with their recreations mightily reinforced those efforts for their moral improvement which I have mentioned.

Now that he is gone from among us, such testimony regarding the man is not inferior in present or future value to the honorable record left by the engineer.

William Robertson Boggs, Jr., was born Mar. 12, 1857, at Augusta, Ga. After receiving a common-school education he entered the Virginia Polytechnic Institute, from which he was graduated in 1877. For the two following years he pursued a special course of study at the School of Mines, Columbia University, N. Y., and in 1880 was made professor of chemistry and physics at Howard College, Marion, Ala. In 1881 and '82 he was occupied as assayer at Leadville, Colo., and from 1883 to '85, inclusive, was metallurgist for the Trevor Hill Smelting Co., at Leadville. In 1886 he went to Rico, Colo., and for two years was metallurgist of the Grand View Smelting Co. From 1888 to 1892 he was successively agent and manager for the St. Louis & Zacatecas Ore Co., of Mexico City, Mexico. In 1893 he became manager of the Harrison Reduction Works at Leadville, belonging to the National Lead Co., and in 1895 and '96 was manager of the Concepcion Mining Co., at Catorce, Mexico. In 1898 and '99 he was metallurgist for Telesfero Garcia at Sultipec, Mexico, and then for the Compañia Metalurgica Argentina, Argentina, until 1905, when he was employed as metallurgical manager by W. B. A. Dingwall, at La Maroma, San Luis Potosi, Mexico, where he was killed Dec. 1, 1907, by employees. The financial stringency had made it impossible for him to pay his workmen promptly, and, becoming enraged, a brutal mob of them met him on the road and stoned him to death. Mr. Boggs became a member of the Institute in 1882.

Thomas Forster Brown was born at Garryill, on the border of Northumberland, in 1835. In 1851, he was articled to Thomas Emerson Forster, an eminent mining engineer in the North of England. In 1855 he became assistant manager of the Stella Coal Company's collieries, and in 1858 manager of the Machen Collieries, Monmouthshire. The latter position he held until 1865. By his advice the Rhos Llantwit colliery was opened up, and he acted as consulting engineer to that company until about 1890, when the pit was exhausted

and abandoned. Meanwhile, Mr. Brown had formed, in 1866, with Mr. Samuel Dobson, a leading engineer for large undertakings, a partnership under the name of Dobson & Brown. This firm (into which, after Mr. Dobson's death, new partners were from time to time admitted—including Mr. Brown's eldest son, Mr. Westgarth Forster Brown) have been associated with many important engineering works, among which may be named the opening and equipment of the Great Western, Deep Navigation, Windsor and other South Wales collieries, and the extensive Durham pits of Bolckow, Vaughan & Co., and the construction of several branch railway-lines, such as the Maesteg & Cimmer, the Ely Valley and the Vale of Glamorgan. Mr. Brown himself retained his active interest in the firm for nearly a quarter of a century, during which time he discharged with honor many individual responsibilities also. He served jointly with Barry and Brunel in the construction of the Barry docks, and was one of a similar board of engineers for the Talbot railway and docks, which were completed in 1900.

In 1890, on the decease of Sir Warington Smythe, he was appointed chief mineral inspector for the Royal Commissioners of Woods and Forests, and for the Duchy of Cornwall.

Mr. Brown's contributions to technical literature were highly valuable, and two of them won reward as well as recognition: namely, his monograph on the South Wales coalfield (1874), for which he received a prize from the North of England Institute of Mining and Mechanical Engineers, and his paper on The Deep Mining of Coal (1881), read before the Institution of Civil Engineers, for which both the George Stephenson medal and the Telford prize were awarded to him.

In 1873, and again in 1891, he was President of the South Wales Institute of Engineers; in 1886, he was elected a member of this Institute; in 1898 he was a member of the Council of the Institution of Civil Engineers; in the same year President of the Mining Association of Cornwall; and, in 1898 and 1899, President of the Mining Association of Great Britain. His death, Oct. 23, 1907, was due to an attack of apoplexy, and may fairly be lamented as premature, even at the age of 72 years and at the end of a continuously active, useful and distinguished career. For what our generation most deeply needs is not the ardor of youth but the

experience and judgment of mature age; and the loss of a wise counselor is an irreparable loss.

Eugene E. Burlingame was born in Pillar Point, N. Y., Nov. 21, 1844. He was the son of Alva and Mary Waterman Burlingame. At the age of 17 he began the study of assaying under the instruction of Dr. A. K. Eaton of New York, where he remained for five years.

In 1866 he left New York for Colorado, and located at Central City, and was soon appointed Territorial assayer for Gilpin county. This position he held four years, leaving it to accept an appointment as assayer and superintendent of a silver-amalgamation mill, owned by Shelby & Co., at Silver City, New Mexico.

After about two years he returned to Colorado, and established in Denver an assay-office, which he continued to conduct until his death, March 20, 1907.

In connection with his assay-business, he was the first to experiment with the fire-clays of Golden, and ascertain to what extent they could be utilized in the manufacture of assayers' supplies, such as crucibles, scorifiers, muffles, etc. The results of his investigations were so favorable that Denver soon became a chief source of supply for these wares, which had been previously obtained, at very high prices, from remote points in the East and even from manufacturers in England. This business (the "mud" business, as he termed it) soon passed into other hands, and is now controlled by the Denver Fire Clay Co.

Another important feature of Mr. Burlingame's business was the purchase of gold and silver bullion, cyanide precipitates, "retorts" from the stamp-mills, etc., not of sufficient fineness for purchase by the United States mint in Denver. The importance of this branch of the business may be gathered from the fact that, during the last 15 years, its annual purchases in this department averaged $750,000, the principal source of this supply being the San Juan district, Colorado. This in itself affords sufficient testimony as to the degree of confidence felt by the Western miners and mill-men in Mr. Burlingame's skill and integrity.

Mr. Burlingame was a man of careful, shrewd business

habits. He was a stanch believer in the future of Colorado, and in the growth of Denver, and a large investor in local real estate. He had been in very delicate health for some years before his death; but he struggled on in harness almost to the last.

Mr. Burlingame became a member of the Institute in 1882, and was always loyally interested in its success.

George V. Devinney was born Oct. 13, 1880, near Dinon, Colo. He graduated as E. M. in 1903 from the Colorado School of Mines, and was first employed by the Canadian North West Irrigation Co., of Alberta, Can., but in October, 1904, removed to Creede, Colo., as assayer for the East Willow Mining Co. In September, 1905, he became engineer for the Colorado Telephone Co., and a year and a half later was appointed assistant engineer and supervisor of construction of the water-system of Greeley, Colo., where he contracted the illness of which he died Aug. 22, 1907.

Mr. Devinney joined the Institute in 1903, and was one of its most promising young members.

George Henry Evans was born July, 1866, at Hull, Yorkshire, England, was educated at private school and college, and studied engineering with his father, a civil engineer of Norwich, England. In 1890 he became general manager and resident engineer of the Round Hill Syndicate Mines at Riverton, New Zealand. In this capacity he had entire charge of all preparatory work on canals and breakwaters, and of all mining operations. After severing his connection with this company, he came to California in 1897, and subsequently served as manager and resident engineer of the Consolidated Gold Mines of California, Ltd., the Mugalia Consolidated, Ltd., the Golden Gate of California, Ltd., the Development Syndicate, Ltd., and consulting engineer of the Risdon Iron Works at San Francisco. Mr. Evans was the inventor of "Evans' Hydraulic Elevator," now widely used in the elevation of gravel. At different times he had charge of the operations on Golden Feather Channel and at the Banner Mine, in Butte county, Colo. He joined the Institute in 1898, and was a member of the American Society of Mechanical Engineers, the Franklin Institute,

the North of England Institute of Mining and Mechanical Engineers, the Technological Society of the Pacific Coast and the Bohemian Club. His death occurred during a surgical operation, at Berkeley, Cal., on the 4th of February, 1907.

James K. Eveleth was born in 1860 at Longmeadow, Mass., went to Montana in 1883, and became chemist and assayer of the old Bell smelter at Butte. After spending a few months in Colorado, he returned to Butte in 1886, and was employed first at the Colorado smelter and afterwards for two years at the Anaconda smelter. He was elected in 1887 a member of the Institute, and in 1889, while at Anaconda, he contributed to the *Transactions* (xvii., 757) remarks on the determination of iron by volumetric analysis, which indicated his accomplishments as a chemist and assayer.

In 1893, after a brief experience as an ore-buyer in Montana, he spent several months in Europe, and subsequently went to Korea to examine mines for California clients. In 1896 he established in San Francisco, Cal., an assay-office, which he maintained for several years. In 1900 he was sent to New Mexico as the representative of the Hearst estate at the Pinos Altos mines; he served the same employers in 1903 as superintendent of their ore-sales to the smelting-works at El Paso, Texas, and in 1905 at the Santa Eulalia Mine, Chihuahua, Mexico. In 1906 he examined mines in Cuba, and in April, 1907, established himself in Utah. He died at Garfield, Utah, Dec. 6, 1907. Mr. Eveleth was an assayer and metallurgical chemist of recognized rank, and enjoyed also a high reputation as a judge of ores and of mines.

William Warren Garrett was born Feb. 11, 1878, at Kentville, N. S. Graduated from the Massachusetts Institute of Technology in 1901, he became assistant in metallurgy at the same institution in the same year. In June, 1902, he accepted an engagement with the Boston & Montana Copper Co., at Great Falls, Mont., as gas-analyst, furnace-man, etc. In 1904 he became instructor in mining engineering at the Missouri School of Mines, Rolla, Mo. After serving a short time in this position he became a superintendent under the American Smelting & Refining Co. In 1905 he joined this Insti-

tute. At the time of his death, Jan. 14, 1907, he was but twenty-nine years of age, and had but just begun to show what he was likely to achieve in his profession.

William Glenn. The death of Mr. Glenn removed one of the most accomplished mining engineers and metallurgical chemists of the United States. Born April 6, 1840, at Norfolk, Va., and graduated in 1855 at the Virginia Collegiate Institute, he entered immediately the service of the Baltimore & Ohio Railroad as an assistant engineer, holding this position until the outbreak of the war of the Rebellion in 1861, when he entered the Confederate army as an engineer officer, and served in that capacity throughout the war. From 1866 to 1884 he was the mining engineer of the Tyson Mining Co., operating mines of chromic iron-ore. In 1884 he became manager of the Baltimore Chrome Works, with the successful direction of which his name was thereafter indissolubly associated until his death. His intimate friendly, as well as professional, relations with the Tysons are indicated in his sympathetic Biographical Notice of James Wood Tyson, mentioned below.

Mr. Glenn became in 1881 a member of the Institute, to which he gave for the following quarter of a century a cordial and unfailing support. In 1899, 1900 and 1901 he was a member of the Council: In connection with the Baltimore meeting of 1892, and with the hospitable preparations made for another Baltimore meeting in February, 1904 (defeated by the disastrous conflagration beginning Feb. 7, by which a large part of that city was destroyed), Mr. Glenn's co-operation was zealous and effective. Although heavily burdened with administrative duties, he found time to make the following contributions to our *Transactions:*

Date.	Title.	Volume.	Page.
1882.	Method of Copper Analysis,	xi	129, 134
1888.	The Electrolytic Assay of Copper,	xvii	406
1891.	Sampling Ores Without Machinery,	xx	155
1894.	Mine-Explosions from Grahamite-Dust,	xxiv	195, 898
1895.	Chrome in the Southern Appalachian Region,	xxv	481
1895.	The Form of Fissure-Walls, as Affected by Sub-Fissuring and by the Flow of Rocks,	xxv	499
1901.	Biographical Notice of James Wood Tyson,	xxxi	118
1901.	Chromite as a Hearth-Lining for a Furnace Smelting Copper-Ore,	xxxi	374

Mr. Glenn was also a Fellow (in the chemical section) of the American Association for the Advancement of Science, and member of the American Chemical Society and the Society of Chemical Industry. He was a contributor to the reports of the United States Geological Survey (see especially his remarks on the geological relations and distribution of chromite in the United States, in Part III. of the 17th Annual Report, for 1895-6); and his papers read before the societies named, or published in technical journals, treated a great variety of subjects, among which (as I infer from a memorandum in his handwriting sent to me, at my request, a year and a half ago) he regarded as most important the geological history of asphalt, copper-ores and chromite; the metallurgy of copper; the chemical technology of alkali dichromates; and the stability of these salts and of chromic acid. I feel sure that any competent judge except the modest author would have made the list longer.

Mr. Glenn died Feb. 16, 1907. To the foregoing inadequate sketch of his professional career, I will only add a word of personal esteem and personal sorrow. He was one of those strong, helpful friends to whom, in the discharge of my sometimes delicate and difficult duties, I could always turn for wise counsel and effective aid, and with whom there was never any time wasted in the explanation of misunderstandings. I think my utterance of love and loss will be echoed by a host of voices—the voices of all who knew him.—R. W. R.

George Byron Hanna was born Oct. 10, 1835, at Holyoke, Mass. After graduation at Brown University, he took, in 1867 and 1868, a post-graduate course in the Columbia School of Mines at New York City. In 1870 he was appointed assistant assayer of the United States Assay Office at Charlotte, N. C., in which establishment he continued to serve until, on May 20, 1907, he died at his post, by a stroke of apoplexy. This remarkable record of thirty-seven years of faithful and efficient service in a Federal office, undisturbed by the vicissitudes of political party rule, is of itself an evidence of Mr. Hanna's faithfulness, ability, and estimable and winning personal character, to which overwhelming confirmation was given by the great gathering of citizens of Charlotte at his funeral, and the

numerous tributes of love and sorrow which his sudden departure evoked from societies, individuals, and public journals.

Mr. Hanna became a member of the Institute in 1887. Besides the efficient discharge of his duties as United States Assistant Assayer, he made valuable contributions to the work of the North Carolina Geological Survey, and to technical journals. In enterprises for the social and moral improvement of his adopted State, and particularly in the work of the Young Men's Christian Association, he was for many years an unwearied laborer and a recognized leader.

Bernard James Harrington was born at St. Andrews, Quebec, in 1848. After graduating at McGill University in 1869, he continued his education at Yale, and in 1871 was appointed lecturer in chemistry and mining at McGill. Subsequently he became chemist and mineralogist of the Canadian Geological Survey, which position he held for seven years. In 1883 he was appointed professor of chemistry at McGill University, holding this post until his death. He was prominent as a writer on scientific subjects, especially on Canadian mineralogy, and held offices in several scientific organizations. He was a member of the American Chemical Society, a Fellow of McGill University and the Royal Society of Canada. Prof. Harrington joined the Institute in 1877, and many of its members have enjoyed his hospitality. He died Nov. 29, 1907, at Montreal. His widow, a daughter of Sir William Dawson, and a family of four daughters and three sons, survive him.

Frank J. Hearne was born Sept. 21, 1846, at Cambridge, Md. After receiving an academic education, he entered the Renssalaer Polytechnic Institute, Troy, N. Y., and immediately upon his graduation as C. E. in 1867, accepted the position of assistant engineer on the Hannibal & St. Joseph Railroad, Missouri. In 1872 he resigned this position, to become assistant general manager of the Riverside Iron Works, Wheeling, W. Va. In 1874, he joined this Institute, then young and far from strong in numbers and influence; and for a considerable period—until his increasing business duties prevented such active participation—his regular attendance at the meetings and his cordial enjoyment of their technical

proceedings and their social fellowship were potent influences for its prosperity and progress. To the small—and, alas! ever smaller—number of our "old" members, the recollection of his handsome, friendly countenance is an unforgotten pleasure.

When the Riverside Iron Works were acquired by the National Tube Co., Mr. Hearne became First Vice-President of the latter organization, in charge of its manufacturing department, with headquarters at Pittsburg, Pa. Upon the retirement of the President of the company, he was elected to that office, which he held until, in 1903, he was elected President and Chairman of the Board of Directors of the Colorado Fuel & Iron Co., the most important enterprise in the manufacture of iron and steel west of the Missouri river, having its great metallurgical works at Pueblo, Colo., and operating numerous mines in other places. He was still occupying this responsible position, and discharging its multifarious duties with credit and success, when he died, Feb. 25, 1907, at the age of 61, in the mature prime of his powers and his usefulness. We are accustomed to lament the premature termination of youthful and promising lives, because it deprives the world of unknown possible treasures of achievement and example. But our sense of loss may well be more keen, because more definite, when a career, of quality and value already demonstrated, is ended without being fully completed. The supply of ardent youth is perennial and inexhaustible. What we need most is the wisdom of experience; and when death deprives us of this, we know that we have lost, not a dream or a hope, but a real and invaluable possession.

Mr. Hearne, in thirty-five years of successful professional and business practice, achieved wide recognition as a technical manager and a "captain of industry" in the iron and steel manufacture, and especially in that of iron and steel tubes, and similar products. Unfortunately, like so many of those who expend their strength in "*doing* things," he found no opportunity to *describe* things, and thus to furnish, for the guidance of his successors, the interesting results of his own experience. It is perhaps, in these strenuous times, too much to expect of the overworked directors of immense industrial undertakings that they shall find time and strength to record and advise, as well as achieve. All the same, we have good cause for lamentation

when they do not leave us this precious legacy, and great reason for gratitude when they do; and, with regard to my dear friend of many years, Frank J. Hearne, I will freely say that, besides my personal sorrow at his death, I regard it as premature and disastrous, especially because, if he had lived a little longer, and had become physically unable to work quite so hard, he might have been persuaded to discharge a duty to his profession, and leave a permanent memorial of himself, by telling what he had learned in the supreme school of practice.

This is a sermon which I have often preached to members of the Institute, though seldom from a more impressive and appropriate text.—R. W. R.

George C. Hewett was born in 1854 at Sheffield, England. Brought in infancy to this country, he received his preliminary education in private schools at Philadelphia, was subsequently graduated as a mining engineer, at the age of 18, from the Polytechnic College of Pennsylvania in that city, and, in this capacity, entered the service of the Westmoreland Coal Co., with which he remained until 1880, when he took charge, as engineer and superintendent of the Hecla Coke Co., of the design and construction of its deep working-shafts. In 1882, he became general manager of the Winifrede Coal & Railway Co., at Winifrede, W. Va., where he remained for about three years. In 1885, he went to Colorado, where he engaged in silver-mining at Aspen, and also in general practice as a consulting mining engineer. During the following seven years, he acted as manager or adviser for many important enterprises, including several of the Aspen mining companies, as well as the coal-mining operations of the Colorado Midland Railway at Sunshine and Vulcan, Colo., and of the Union Pacific Railroad at Rock Springs, Wyoming.

Returning to the East, he became in 1894 the fuel-agent of the Southern Railroad Co., with headquarters at Atlanta, Ga., and in 1897 general manager of the Corona Coal & Coke Co. In 1898 he returned to the West and opened an office as consulting engineer at Colorado Springs, Colo., where he died suddenly, Aug. 12, 1907, of heart-failure.

At the time of his death, he was consulting engineer for the Colorado Springs Co. (owned by Gen. W. J. Palmer), the

London Mining & Tunnel Co., the Bullfrog Victor Gold Mining Co., the Anthracite Mesa Mining Co., the Durango Coal & Land Co., and other Colorado mining enterprises. He was a member, and in 1901 the President, of the Colorado Scientific Society, and a Trustee of the Carnegie Library at Colorado Springs.

Mr. Hewett was elected a member of the Institute in 1883, and maintained until his death not only his formal membership but also an active and helpful interest in its proceedings and prosperity. He contributed to the *Transactions* a valuable paper on The Northwestern Colorado Coal-Region (*Trans.*, xvii., 375), and contributions in discussion of the geological section across the Sierra Madre Occidental of Mexico, the gold of the Homestake vein in the Black Hills of South Dakota, mine-explosions, etc.

In every position occupied by Mr. Hewett during his active and varied professional career of twenty-five years, he won the respect and esteem of his associates, employers and subordinates. During his second sojourn in Colorado, he distinguished himself by his courageous and outspoken condemnation of the performances of the Western Federation of Miners, which so nearly paralyzed the mining industry of that State. His death, at the comparatively early age of 53, has deprived Colorado of a useful and influential citizen, mining engineering of an able, upright and admirable representative, and many mourning survivors of a dear and loyal friend.—R. W. R.

Thomas Edward Johns was born Jan. 22, 1879, at Camborne, Cornwall. He was educated at the Camborne schools until he was thirteen. From 1892 to 1896 he worked in the Dolcoath mine, Cornwall, and from 1896 to 1901 pursued engineering studies. In 1901 he went to South Africa and took a post as surveyor to the Ferreira and Worcester Companies. He remained with these companies until 1906. From April, 1906, to November, 1906, he was manager of the prospecting work undertaken by the Transvaal Consolidated Land Co., near Pietpotgietersrust in the Watersberg district. He joined the Institute in 1904, and died in November, 1906.

William J. Johnston was born at Ballycastle, County Antrim, Ireland, in 1853. He came to the United States in 1868, and was first employed as a telegraph operator. In 1874, when *The Operator*, a paper founded by several Western Union employees, was first issued, he became at once a contributor. In 1875 he was part-owner of the paper, and in Jan., 1876, sole proprietor and editor. The Western Union Company ordered him to give up the paper, and, in consequence of the order, he resigned from their service. In 1883 he changed the name of his periodical to the *Operator and Electrical World*, and in 1883 dropped the name "Operator" altogether. In 1889 he sold the *Electrical World* and took a trip around the world. In 1900 he began the publication of a periodical called *Mining and Metallurgy*, and in 1901 this was merged into the *Engineering and Mining Journal*, of which he had become part-owner. In 1903, while still connected with the *Engineering and Mining Journal*, he founded a paper called the *Pacific Coast Miner*, and shortly afterwards severed his connection with the *Engineering and Mining Journal*. In 1904 he founded the *Mining Magazine*, which he sold in 1906. During the year 1905 he bought an interest in the *American Exporter*, of which he became later the sole owner. In the interest of his paper he took another trip around the world, and several foreign trips, to study export trade-conditions. He had brought the journal to an excellent position at the time of his death from cerebral hemorrhage, which occurred April 28, 1907. Mr. Johnston was a man of sanguine disposition, extraordinary persistency of purpose and indefatigable industry. These qualities earned for him positions of prominence in the successive fields in which he labored up to the period of his untimely end. He became an associate of the Institute in 1901.

James F. Jones was born July 11, 1839, in Wales. He died suddenly, Nov. 6, 1907, at Philadelphia, Pa., having been a member of the Institute since 1888. The following account of his career is condensed from *Mines and Minerals*, Scranton, Pa., for January, 1908.

In 1862, at the age of 23, Mr. Jones went for three years to Sydney, N. S. Wales, whence he returned to Wales, and, after a few weeks there, came to America, and settled at Shenandoah,

Pa., as a contract miner, chiefly engaged in driving gangways. From the large profits earned at that period by contract mining, he saved in three years enough to enable him to gratify his desire for greater technical education. He removed to Pottsville, where he studied under a private tutor and in schools, until in October, 1869, he secured a place as chainman in the engineering corps of the late Gen. Henry Pleasants, under whom he served for many years. In July, 1873, Gen. Pleasants, as chief engineer of the Philadelphia & Reading Coal & Iron Co., made him resident engineer of the Ashland district; in 1881, he was appointed assistant mining engineer, and, six months later, chief mining engineer of that company. Resigning this position Oct. 31, 1882, he became chief engineer and general manager of the Oregon Improvement Co., with headquarters at Seattle, Wash. From 1886 to 1893, he was consulting engineer of the Philadelphia & Reading Railroad and Coal & Iron Companies; and from the latter date until his death he practiced on his own account as a mining engineer. His splendid physical strength and mental ability, power of sustained endeavor, intense industry and earnest ambition enabled him to lift himself from the rank of an uneducated miner to the position of chief engineer of the largest coal-mining corporation in the world, and to win for himself a position of recognized eminence in his profession.

Clermont Livingston was born Oct. 15, 1850, in London, England. After leaving school, he entered commercial life. For a number of years he was chartering agent of the Peninsula & Oriental Steamship Co. His connection with mining began with a concession in Swaziland, South Africa. In 1897, he went to Canada and became interested in mining at Mount Sicker, Vancouver, B. C. In 1899, he became general manager of the Tyee Copper Co., and in 1902, took charge of the Vancouver Island Mining & Development Co., both English corporations operating on Mount Sicker. He was elected to membership in this Institute in 1905, and died Oct. 20, 1907. Mr. Livingston's hospitable reception, in 1905, of the Institute party which visited the Tyee Copper Co.'s mines, made friends of all his guests; and the loss which the mining industry of Vancouver Island has suffered through his death is felt also by

many who had learned to regard him as an honest, ardent and successful pioneer, as well as an accomplished and genial host.

Frederick William Matthews was born Mar. 14, 1849, at Tavistock, Devon, England. After graduation from the Government College at Chester, he served his time as an articled student and assistant with Harvey's Hayle Foundry, in Cornwall, and, during that period, was sent by that firm to superintend the erection of a large pumping-plant in the Argentine Republic. This doubtless led to his subsequent employment as chief engineer of the Sombrero Phosphate Co., operating in the West Indies, and managing engineer of the Callao Gold Mining Co., in Venezuela. In 1883, he went to the South African diamond-field, where he was employed for from five to seven years, chiefly in the erection of diamond-washing machinery. From about 1890 to the end of 1892, he was engaged as chief engineer for several companies on the West Rand, near Johannesburg, in the erection of their mining machinery. In 1893 and 1894, he served as assistant engineer, in special charge of machinery, of the town of Johannesburg. From 1895 to 1899, he was employed in erecting mining machinery for companies operating on the East Rand. From 1899 to 1902, he conducted borings with the diamond-drill in the Dundu coal-field of Natal, subsequently returning to Johannesburg as the engineer of the East Rand Proprietary Mines. This position he held at the time of his death, about the end of 1906. Mr. Matthews became a member of the Institute in 1904.

Robert Sayre Mercur was born Mar. 25, 1868, at Wilkes-Barre, Pa. His father, the late Frederick Mercur, for many years general superintendent of the Lehigh Valley railroad lines, and also an eminent mining engineer, was one of the 22 persons who met at Wilkes-Barre in May, 1871, to organize the Institute, of which, in 1900, the son became a member.

Graduating at Lehigh University in 1890, Mr. Mercur entered in 1891 the service of the Lehigh Valley Coal Co., in which he rapidly advanced to the successive positions of division engineer and division superintendent, becoming in 1904 superintendent of the Kingston Coal Co., Kingston, Pa. On

May 11, 1907, while inspecting the work of repair at one of the collieries of this company, he suffered a fall (supposed to have been caused by a sudden heart-failure), from the effects of which he died, adding another name to this year's unusually long catalogue of active and able engineers cut off in their early prime.

Charles A. Molson was born in 1862 at Montreal, Canada. He was a graduate of McGill University, and, after several years spent chiefly in the western and northwestern provinces of the Dominion of Canada, in the service of the Canadian Geological Survey, began his strictly professional career with the Pueblo Smelting & Refining Co., at Pueblo, Colo. This position he left to enter the service of the Granite Mountain Mining Co., owning important mines at Phillipsburg, Mont. Subsequently, he became manager of the Elkhorn mine, in Jefferson county, Mont., which had been purchased by an English company. In 1895 he resigned this position, in which he had won a wide reputation for ability and integrity, to accept the duties of a professional adviser to English companies, the chief of which was the well-known Exploration Co., Ltd., of London. For the ten years preceding his death, Nov. 26, 1907, he was advisory engineer to this corporation, and also pursued his profession as a general consulting engineer. His reputation as an expert was very high; and he was universally loved as well as respected. Mr. Molson joined the Institute in 1887.

John Fossbrook Morris. Mr. W. H. Shockley contributes, in addition to the obituary notice published on page 677 of the *Bi-Monthly Bulletin* of July last, the statement that Mr. Morris was in Szechuan, Western China, when the "Boxer" insurrection broke out, and fled through China to Burmah, where he arrived after a journey full of hardship and peril, which has been described in a book published by Dr. Jack, formerly the Government geologist for Queensland, the leader of the expedition. From January to May, 1905, Mr. Morris was Mr. Shockley's assistant upon an expedition undertaken for the "Tokar Syndicate" in the Eastern Soudan, on the Eritrean border, during which he rode more than 2,000 miles on camel-back. His most interesting discovery was an outcrop of anthracite which, although apparently of inferior quality, may prove to be im-

portant in the future development of a vast region hitherto regarded as destitute of mineral fuel.

In 1905, before going to Singapore, Mr. Morris made an examination of old copper-mines in Ireland. As Mr. Shockley adds, he was an engineer of great promise, intensely interested in his profession, and eager to increase in every way his knowledge of it; and his death on the Malay Peninsula, at the early age of 26, "was probably caused by too great zeal for his employers, and forgetfulness of the fact that the most important duty of an exploring engineer is to protect his own health, upon which everything intrusted to him depends. This is something that young engineers, especially in tropical countries, are too apt to lose sight of."

Louis Pelatan was born Sept. 25, 1854, at Paris, France. At the age of 19, he entered the Ecole des Mines Supérieure, from which he was graduated in 1876 at the head of his class. He was immediately appointed assistant engineer by the Société des Mines of Escombrera, Spain, where he remained until 1878, when he became a consulting engineer of the firm of Rothschild Brothers, in which employment he had headquarters at Paris and Madrid, and visited and inspected various mining properties controlled by that house. From 1882 to 1885, he was chief engineer of the Société Le Nickel, operating nickel-mines in New Caledonia. From 1885 to 1890, he was manager of the Pilon copper-mines and the Fernhill gold-mine, in the same province. During this period he executed a valuable geological map of New Caledonia, for which service, added to other claims, he received from the French government, in 1889, the decoration of Chevalier de la Légion d'Honneur.

In 1890, for reasons of health, he returned to Paris, where he enjoyed until his death an influential position and large practice as consulting mining engineer and director of various gold, copper, zinc, silver, lead and iron mines. He made a number of professional visits to the United States, becoming in 1894 a member of the Institute. Among his published works was a monograph on the resources of the French colonies, which was republished in the *Revue Universelle* of Liége.

Mr. Pelatan was famous also through his connection with

the Pelatan-Clerici variation of the cyanide process for the treatment of gold-ores.

He died June 2, 1907, of injuries received in a railway-accident.

Alfred Mayer Rock was born Sept. 26, 1877, at Washington, D. C., and graduated from Howard University in 1900, when he at once entered the government service, receiving employment in the U. S. Geological Survey. He served as field assistant at Rico and Silverton, Colo., from July to September, 1900; at Bisbee, Ariz., from September, 1900, to January 1903; and at Cripple Creek, Colo., until February, 1904.

In 1904 he was made mine-surveyor for the Federal Lead Co., and in April of that year took charge of the diamond-drill prospecting-department of the company, at Flat River, Mo. At the time of his death he was with the American Smelting & Refining Co., at the Santa Francisca mine, Asientos, Mexico. On the 7th of August fire broke out in the mine. Mr. Rock and the superintendent went underground, to aid in placing bulkheads and getting the miners out. They were among the last to seek safety; and both were asphyxiated, after they had climbed to the first level and while they were crawling through a drainage-tunnel towards the surface. A rescuing party found Mr. Rock's body; but he was beyond resuscitation. He was a man without fear, indefatigable, scrupulous, and of a buoyant, cheerful disposition; and was fast rising in his profession. He became a member of the Institute in 1904.

George William Rose was born Oct. 4, 1873, at Big Rapids, Mich., and spent the years from 1892 to 1895 in the study of mechanical engineering and chemistry at the Michigan State College. From 1897 to 1899 he was assayer at different mines in the Tintic district, Utah. In 1900 he became accountant for the Glasgow & Western Express Co., of Salt Lake City. From 1901 to 1903, he was superintendent of the California stamp-mill of J. R. De la Mar. In the summer of 1903, he became cyanide chemist and foreman of the Octave Gold-Mining Co., Octave, Ariz., holding that position until, in October, 1904, he returned for a couple of years to Salt

Lake, where he was employed by the Glasgow Exploration Co. During this period (in 1904) he was elected a member of this Institute.

In January, 1906, he was engaged by the Mexican Milling & Transportation Co., of Guanajuato, Mex., where he was so successful in making the old cyanide-works of the company profitable that he was put in charge of a new 200-ton mill, which he had had a large part in designing. It was here that he lost his life, while defending his wife and daughter from the attack of two heavily-armed Mexican burglars, on the morning of Sept. 11, 1907. The family had been awakened by the entrance of these men, who, finding themselves discovered, attacked Mr. and Mrs. Rose with dagger and machete. In the ensuing struggle Mr. Rose was fatally stabbed, and the robbers escaped. His wife was badly wounded, but subsequently recovered; and their daughter (a child of five years) was unhurt.

Mr. Rose was an ardent and constant student of metallurgy; and his untimely death at the age of 35 cut short a career which promised much for the advance of metallurgical theory and practice, especially in the varied applications of the cyanide process.

Gilbert Cuthbert Simpson was born Dec. 27, 1874, at Glasgow, Scotland, and educated at the Glasgow and West of Scotland Technical College, where he pursued a four years' course of study in chemistry and metallurgy. In January, 1896, he became assayer for the Refugio Mining & Milling Co., of San Julian, Parral, Mexico, where he stayed until October of the following year. From October, 1897, to February, 1898, he was employed by the Anita Mining & Milling Co., and the Capuzaya Mining & Milling Co., of Guanacevi, Durango, Mexico. From February, 1898, to January, 1901, he was ore-buyer for the Lewis Co., at Guanacevi, Topia, Culiacan and Mazatlan, and in February, 1902, he became associated, at Chihuahua, Mexico, with the American Smelting & Refining Co., in the employ of which he remained until a short time before his death. He died June 8, 1907, of a hemorrhage from the lungs, at El Paso, Tex., where he had gone to purchase an assaying and chemical outfit, preparatory to

opening an office of his own in Chihuahua. Mr. Simpson joined the Institute in 1902.

Thomas William Patrickson Storey was born at Lancaster, England, in 1870. In later years he was manager of the Kisham Mining Co. and the Castle Limestone Co., and assistant manager of the Darwen and Mostyn iron-works in North Wales. He was a member of the Institution of Civil Engineers and the Iron and Steel Institute, and joined this Institute in 1906, becoming a life-member. He died Mar. 15, 1907, after a short illness.

Sydney Thow was born Sept. 18, 1873, at London, England. Having emigrated to Australia, he was professionally educated at the University of Adelaide and the Engineering School of Sydney University, from which he was graduated in 1891. In 1892 he was employed in the engineering shops of Hudson Bros., at Sydney, and for the following two years by Baxter & Saddler, railway contractors in New South Wales. During 1894 and 1895 he was a draftsman in the Locomotive Department of the Government Railway of New South Wales, and subsequently, until the end of 1896, he was in the service of the Smelting Co. of Australia. Removing to Tasmania, he was professionally connected in 1897 and 1898 with the Mt. Lyell Mining & Railway Co. For the next four years he practiced as a consulting engineer at Sydney, N. S. W. In 1902 he was appointed general mining manager of the Hercules Gold & Silver Mining Co., Mt. Read, Tasmania, and consulting engineer to the Magnet Silver Mining Co., in which positions he remained until his death, which occurred June 24, 1907. He became a life-member of the Institute in 1902.

Eugene B. Willard was born at Hanging Rock, O., Oct. 19, 1874. His grandfather, James O. Willard, was one of the pioneer ironmasters of the Hanging Rock district; and his father, Eugene B. Willard, whose name he received and worthily bore through a brief but honorable career, followed the same occupation in the same region. He was thus designated, by heredity and tradition, as well as by personal fitness, for the profession which he adopted, and which has lost so much through his early death. He took the civil engineering course at

Pennsylvania Military College, where he was graduated in June, 1894. In September of that year, he became blast-furnace foreman for Means, Kyle & Co., of Hanging Rock, O., for whom, in addition, he made surveys and maps of their properties. From October, 1897, to June, 1899, he was a special student in chemistry at the Case School of Applied Science in Cleveland, O. He became a member of this Institute in 1900, and of the Iron and Steel Institute in 1904. For eighteen months after leaving the Case school he was employed at the Hamilton furnace of the Hanging Rock Iron Co., at Hanging Rock, O., and for the two following years in connection with the construction and operation of the second furnace of the Iroquois Iron Co., at South Chicago, Ill. For the next four years he had charge of three stacks of the Wellston Iron & Steel Co., at Wellston, O., and, in July, 1906, was made manager of the Eliza Furnace No. 1, belonging to Jones & Laughlin, at Pittsburg, Pa. He was killed May 21, 1907, by an explosion at this furnace. The year's record of such calamities is exceptionally long and sad, and involves the premature sacrifice of many educated, ambitious and already useful young men, whom their profession and the world could ill afford to lose. In this lamentable list, the name of Mr. Willard deserves a high place.

John A. Walker, Vice-President and Treasurer of the Joseph Dixon Crucible Company, died at his home, Jersey City, N. J., on May 23, 1907. Mr. Walker was born in the city of New York, September 22, 1837. He received his early education in the schools of Brooklyn, and, although prepared for college in a private school, chose commercial life. After an excellent business training in the city of New York, and after serving his country in the war of the Rebellion, Mr. Walker in 1867 became connected with the firm of Joseph Dixon & Company, of Jersey City. In 1868, when Joseph Dixon & Company became incorporated as the Joseph Dixon Crucible Company, he was made secretary of that company, and began his life-work in making known to the world the many uses of graphite, of which the Joseph Dixon Crucible Company has been the most widely known exponent.

Mr. Walker served this company as its secretary and prac-

cally its manager until 1891, when he was unanimously elected to the dual position of Vice-President and Treasurer, the latter office having been held by him for some time previous. These offices he retained without interruption until his death, the general management of the company also being largely in his hands.

In stature Mr. Walker was somewhat below the average, but, born of sturdy Scotch parents, he was a good type of the nervous, driving, untiring, persistent Scotchman, and he possessed a large, finely-shaped head. In intellect he was keen, clear, critical, intuitive. In business he was thoughtful, cautious in looking ahead and preparing for emergencies. He had what is known as a wiry organization. His moral brain made him a just man. He was of the stanch Presbyterian school. What he believed to be right he did—no matter what others might do or say. Yet he was not contrary, not set in his ways, nor unreasonable. While his sympathies were keen and easily aroused and his hand ready to open, yet no one found him wasting anything. He was shrewd, energetic, liberal-minded and greatly enjoyed a good joke and plenty of fun in its place. Nothing escaped his eye. He had decided literary tastes and could put them to the test any day, either for business purposes or for an ethical cause.

Untiring and persistent devotion to business, however, with increasing age and lack of needed rest and recreation, began to tell on his vigor and strength, and on April 24 he went home for what he and his intimates supposed would be a few days' rest. Complications set in and a month later he was at rest forever.

As Vice-President and Treasurer of the Joseph Dixon Crucible Company he had more than work enough for any ordinary man; yet, outside of these duties he served as Vice-President of the Colonial Life Insurance Company, director of the New Jersey Title Guarantee & Trust Company, the Pavonia Trust Company, the Provident Institution for Savings, and President of the Children's Friend Society—all of Jersey City—trustee of the Stationers' Board of Trade of New York, First Vice-President of the National Stationers' and Manufacturers' Association, member of the Chamber of Commerce of New York and of the Board of Trade of Jersey City, Chair-

man of the Executive Committee of the Cosmos Club of Jersey City, member of the Carteret Club, the Union League Club, and the Lincoln Association (all of Jersey City), member of the National Geographic Society, and associate of the American Institute of Mining Engineers, and of the Society for Psychical Research. Moreover, he was at various times member of the Jersey City Board of Education, and trustee of the Jersey City Public Library and of other city institutions.

In all these positions, he exhibited loyalty, zeal, tireless energy, and supreme executive ability. He joined the Institute in 1878, modestly preferring to be elected as an associate, though his practical knowledge of the mining and concentration of graphite amply qualified him to be a member; and for many years he attended its meetings and took part in its excursions, with evident keen enjoyment of the professional and social fellowship thus opened to him. Many of our early members and their families will remember always his beaming cordiality on such occasions—to which he always came loaded with beautiful cases of "Dixon pencils," for complimentary distribution. Yet this was but a characteristic expression of the personality behind it, which, throughout his life, made innumerable friends, and lost none.—R. W. R.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Genesis of the Lake Valley Silver-Deposits.

BY CHARLES R. KEYES, SOCORRO, N. M.

(Toronto Meeting, July, 1907.)

CONTENTS.

I. Introductory.

Lake Valley, New Mexico, has long been one of the most widely known mining districts of southwestern United States. For many years its silver-mines have been among the most famous of the country, visited by many mining men and geologists; yet little information regarding the origin of the ore-deposits and the influencing geologic conditions has found its way into print.

With the recent revival of public attention, after a decade and a half of utter stagnation, to the mining of silver in the Southwest, special interest attaches to the genesis and geologic disposition of the ore-bodies which are so finely open to inspection in the Lake Valley district. Moreover, the local features here described are typical of the conditions existing over a much larger field. The fact that the ores are chiefly the chloride and the chloro-bromide of silver adds further interest. Data bearing upon the genesis of haloid ore-deposits are, at the present time, very much sought. Arid regions offer particularly favorable conditions for the formation of such ores. This New Mexican district appears to supply solutions to many problems concerning this class of ores, which have long vexed the student of ore-deposits.

II. Location and History.

The town of Lake Valley is situated in Sierra county, in the southwestern part of New Mexico, and 100 miles northwest of El Paso, as the crow flies.

From a mining standpoint, the location of the place is itself suggestive, as it lies on the southeastern slope of the great quaquaversal arch of the Colorado plateau. The center of this vast dome is in north-central Arizona, and radii about 150 miles in length reach its foot in all directions. Around its basal margins runs the broad mineralized belt containing most of the great mines of the Southwest, which extends from south-central Colorado southward and southwestward through New Mexico, thence westward through Arizona, northwestward and northward through southeastern California and western Nevada, and, finally, eastward through Nevada and Utah into Colorado again. This great mineralized belt is important as geographically limiting profitable mining over the greater part of five States.

Beyond its confines, mining is to be indulged in with the utmost caution.

The recognition, upon tectonic grounds, of the great ore-bearing zone should have a direct and far-reaching influence upon the systematic exploration for mineral products throughout southwestern United States.

The history of the camp of Lake Valley need not be here narrated, except so far as to correct some erroneous statements of long standing, and to connect the names of several distinguished mining men and scientists with the various enterprises. The discovery of silver in the district was made in 1876 by Mr. McEverts, a cattle-man, who located several claims, which afterwards yielded some of the richest ores. Two years later, while stopping at the McEverts ranch, Mr. George W. Lufkin, a civil engineer from New Jersey, saw specimens of the high-grade silver-ores, and immediately acquired a half-interest in the property. From this time on the development of the camp was rapid. Among the eminent names connected with the various enterprises of the district, at one time or another, may be mentioned those of George Lufkin, George D. Perkins and Whittaker Wright, of Philadelphia; Dr. F. M. Endlich and Prof. E. D. Cope, scientists of the Hayden governmental surveys; Ellis Clark (who has left us the only succinct account of the mine-operations), E. W. Hadley, and S. A. Miller and Frank Springer, who first determined the exact geological age of the country-rocks.

The fickleness of fortune is exemplified in the case of Lufkin, who, after sinking a shallow shaft, sold out his interests for a song. Before his successors had pushed the work in the shaft 2 ft. deeper they struck the "Bridal Chamber," a small pocket of very high-grade ore, which yielded more than $1,000,000.

III. Surface-Relief.

The rugged topography of the region immediately about Lake Valley derives its characteristic features from the differential weathering of strongly-tilted rock-layers under unusual conditions of climate, and the vigorous activity of geologic agencies unknown in more humid regions. The alternation of thick beds of very resistant limestones, or of eruptive sheets, and soft shales, in faulted and highly inclined strata, has given

to the relief extreme and unfamiliar characters, the most striking of which are series of long, deep, sharp-bottomed, parallel valleys, worn out of the thick shale beds, and separated by high, serrated ridges made by the harder layers. This is probably the main reason that the rich silver-ores lying on the surface escaped the notice of the early Spanish explorers and adventurers, although the locality was less than half a dozen miles from one of the principal trails, traveled for more than three centuries. For the location of the ore-deposits, in the bottom of a deep, secluded valley, surrounded on all sides by mountains and hills, and with no marked drainage-ways leading into it, naturally tended to leave them to be discovered by mere accident, rather than by intelligent search. This was, in fact, what happened. The first location was made, not by a mining man or even a prospector, but by a *ranchero* of the neighborhood, who afterwards learned from others the value of what he had thus acquired.

The peculiarities of the surface-relief and of the degradation of the district thereby conditioned, have had, as will be seen, an important effect in the segregation of the ore-bodies. The main drainage is northward through the parallel valleys and with the strike of the rocks. In very recent times a change has begun to take place in the eastern part of the area, and narrow dip-valleys have been developing through head-water erosion, so that now the storm-waters of the mining belt are largely carried out through the new channels instead of the old strike-valleys. As explained below, the economic effect of this drainage-change has been to permit the escape of most of the impounded underground-waters of the mining belt, together with the mineral, as fast as it was converted into soluble forms. Instead of being merely deposited a little farther down the slope, as had been the case since the time of the Berenda faulting, the greater part of the original ore-body has been, in this way, gradually lost.

IV. General Geological Features.

1. *Main Relationships and Map.*—In the consideration of so small a district, its relationships with those of the great Colorado dome are almost completely lost. Moreover, in so limited an area the most striking local geotectonic feature is

really the block-mountain, on a diminutive scale. The main geologic characteristics of the district are indicated on the accompanying sketch-map, Fig. 1.

2. *Résumé of Geologic History.*—The later geologic history of the district, which has to do directly with the formation of the ore-deposits, may be briefly summarized as follows:

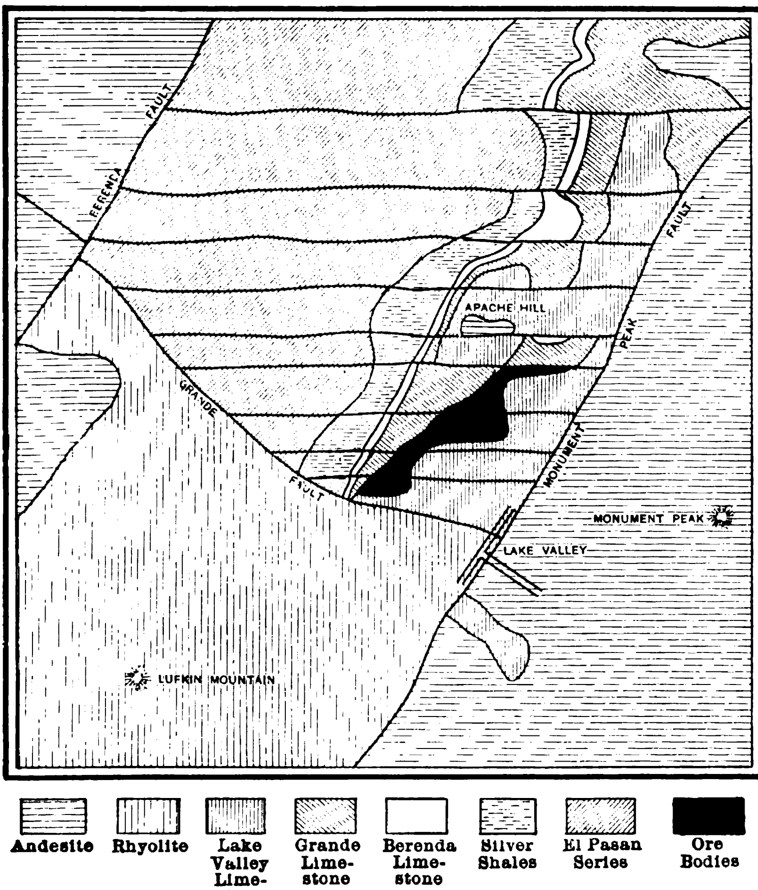

FIG. 1.—GEOLOGICAL SKETCH-MAP OF THE LAKE VALLEY DISTRICT, SHOWING FAULTS.

(1) Rhyolitic eruptions, accompanied by important local mineralization of the bedded rocks at and near the contacts.

(2) The "Grande" faulting, profound and trending northwest and southeast; much more marked, however, beyond the limits of the district.

(3) Vigorous erosion, the most obvious effect of which upon the local surface-relief was marked planation.

(4) Andesitic outpourings, not all confined to a single period, resulting mostly in comparatively thin sheets, but covering a wide scope of country, and almost entirely hiding the stratified rocks.

(5) The "Berenda" faulting, trending northeast and southwest, causing a marked tilting of the rocks, bringing again to the surface the old Paleozoics, and inaugurating local conditions highly favorable to the segregation of ore-materials.

(6) Marked erosion, greatly accentuating through differential effects the local geologic structure and aiding the formation of important ore-bodies.

(7) The "Bella" faulting, consisting of minor, closely-grouped parallel dislocations trending east and west, and often sharply limiting ore-bodies.

(8) Modern erosion, affecting ore-deposition, first, by notable localization, and then by notable impoverishment.

The events thus enumerated in sequence are only those which have been most intimately connected with the local segregation of the ore-bodies. They are all subsequent to the formation of the Colorado dome, and the main epochs of ore-concentration around its base. The full consideration of the last-mentioned event belongs more properly to a broader treatment of the regional geology than to a local description.

V. Geologic Formations Represented.

1. *Broader Considerations.*—The base of the southeastern slope of the Colorado dome is of special interest stratigraphically, because it is a sharply-defined line, separating a vast area, from which the entire Paleozoic section is absent, from another immense region, throughout which the Paleozoics are very fully represented. Within the boundaries of the first mentioned more northerly area, only the two uppermost Paleozoic terranes are represented. Middle-Carboniferous limestones rest directly upon the oldest Azoic gneisses and schists. In the more southerly area, every system of the Paleozoic section is present. In the northern region of New Mexico, these Carboniferous formations are the chief ore-carriers, while in the southern region, the ores are found through several thousand

feet of Paleozoic rocks, wholly unrepresented in the north. In every way the two regions are strongly contrasted.

Lake Valley is on the border line just described. Hence, its geologic section has both a mining and a geologic importence which it would not otherwise possess. It is also espeaially instructive since it is, in almost every respect, the exact counterpart of the standard Devono-Carboniferous section of the Mississippi valley. The recent recognition of this resemblance has been fully considered in another place.[1]

The definite determination of the geologic age of the different rock-formations in which the ore-deposits of this region are found acquires practical value by enabling the search for ores to be quickly narrowed to limited horizons. This fact is strikingly illustrated in the neighboring districts, where the rocks have been repeatedly and profoundly faulted, and otherwise disturbed. But, even in the Lake Valley district, notwithstanding the clearness with which the geologic formations are displayed, a large amount of unwise and futile prospecting work has been done.

2. *Geologic Section.*—The high tilting of the rock-layers gives within the distance of less than a mile an exposed section, complete without a break, as shown in Table I.

TABLE I.—*Geologic Section at Lake Valley.*

	AGE.	FORMATIONS.	THICKNESS.	ROCKS.
CENOZOIC.	Quaternary.		100 feet.	Gravels and Loams.
	Tertiary.	Monument. Lufkin.	250 ft. 500 ft.	Andesites. Rhyolites.
PALEOZOIC.	Carboniferous.	Sierra. Lake Valley. Grande.	50 ft. 150 ft. 25 ft.	Gray Limestones. Shaly Limestones. Blue Limestones.
	Devonian.	Berenda. Bella. Silver.	50 ft. 60 ft. 100 ft.	Nodular Limestones. Green Shales. Black Shales.
	Silurian.	Santa Rita.	10 ft.	Drab Limestones.
	Ordovician.	El Pasan Series.	600 ft.	Dark Limestones.

[1] *Proceedings of the Iowa Academy of Sciences,* vol. xiii., pp. 197, 198 (1906).

3. *Nomenclature.*—Some of the geographic titles of the formations have already come to have a much wider than local application, for which reason it is thought advisable to retain, not only these, but all of the local names. A further reason is that the Lake Valley section is typical for the region, and that the several terranes were here first recognized and described. The geologic ages of the several formations have recently been attested by extensive collections of fossils.

4. *El Pasan Limestones.*—The El Pasan series[1] of limestones, so well displayed in the Franklin mountains north of El Paso, is exposed at Lake Valley with more than 600 ft. thickness, and is doubtless much thicker. The organic remains found in it appear to be the same forms as occur abundantly 100 miles to the southeast. Little doubt is entertained that the rocks are Ordovician in age. The series appears to comprise several well-marked subdivisions. Detailed faunal inquiries will soon delimit clearly the different members. In many localities in the Southwest, these limestones cannot be lithologically distinguished from the overlying Devonian and Carboniferous blue and gray limestones. When the dark-colored Devonian shales are absent, as they often are, the limestones form an unbroken succession of great thickness.

The limestone range west of the mines is called the Quartzite ridge. This title is misleading. The quartzitic aspect is occasioned by large masses of weathered flint, which extensively cover the surface. Since no part of the series carries any ores in this locality, and its subdivision into minor members is unimportant in the present connection, it demands no further description here.

5. *Santa Rita Limestone.*—Exposed in shafts sunk to the Ordovician formations there is found, immediately overlying the latter, a dark compact lime-rock, about 10 ft. thick. The crevices, cracks and uneven places in the surface are filled by a fine, bright red clay, appearing at first glance like a peculiar reddish lime-rock. The formation is doubtless very much thicker elsewhere in the neighborhood; and it is also absent entirely in other places, owing to the marked unconformity, due to erosion, which exists between it and the later terranes.

[1] See *American Journal of Science*, Fourth Series, vol. xxi., p. 298 (1906).

This limestone is probably a remnant of the true Silurian formations, exposed a few miles to the west, and also to the southeast, of Lake Valley. The name Santa Rita has been suggested for the formation. In the vicinity of Santa Rita and Silver City, 30 miles west of Lake Valley, abundant fossils found in apparently the same terrane suggest typical Silurian forms. Still farther west, in eastern Arizona, Reagan[3] has discovered a similar lime-rock, 70 ft. thick.

6. *Silver Shales.*—This remarkable bed of black argillaceous shales appears to form the base of the Devonian section of the region. Thus far it has proved to be non-fossiliferous. Its age is deduced from its stratigraphic position; and it is believed to be the eastward extension of a similar black shale found near Silver City, which has been called Silver shales—a name which is here retained.

Although the Silver shales have no direct relationship with the Lake Valley ore-bodies, they have been largely prospected, and many shafts have penetrated these strata.

7. *Bella Shales.*—The green shales so well exposed in many outcrops have been encountered also in the shafts of the Bella workings. Their lithologic characters are the same as those of the black shales beneath. They do not appear to carry recognizable organic remains at any point in the immediate vicinity of Lake Valley. The geologic position and character of the two great shale beds are significant.

8. *Berenda Limestone.*—The so-called nodular limestone of this district immediately underlies the principal ore-bearing formation, with a thickness of about 50 ft., and comprises three distinct and easily recognizable members.

The lowest is a limestone, 10 ft. thick, gray, massive, compact, and resembling somewhat lithographic stone. It weathers rusty brown and is then somewhat laminated. It carries a typical Late Devonian fauna.

The median member, about 30 ft. thick, is gray, thinly-bedded, apparently without organic remains of any kind, and presents in individual layers only the lithographic texture. It weathers irregularly, having on exposed surfaces a notably nodular appearance. There is little or no chert in it.

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[3] *American Geologist*, vol. xxxii., p. 278 (1903).

The upper member is not more than 10 ft. thick, bluish in color, rather thinly-bedded, composed very largely of chert in elongated nodules and nodular bands, and, so far as known, without fossils. This member contrasts strongly with the massive compact blue limestones lying immediately above.

The entire Berenda formation is also known locally under a number of other titles.

9. *Grande Limestone.*—All the Lake Valley silver-ores are found in this formation. They were first opened at the Sierra Grande workings, and are confined chiefly to the upper part of this tri-partite terrane.

At the base of the formation is a massive, hard, grayish-blue coralline lime-rock, from 13 to 15 ft. thick. Above this is 2 ft. of black, sub-crystalline limestone, carrying abundant large corals and gastropods. The upper member, 10 ft. thick, consists of blue, compact, heavily-bedded, pure, soluble lime-rock, with but few fossils.

Above permanent water-level this formation is usually more or less cavernous. It is at this level that the ores are chiefly segregated. Much massive chert is also accumulated in the old caverns and crevices.

The Grande limestone terrane appears to correspond to the Chouteau limestone of the standard Mississippi Valley section. Special attention has been recently called to this fact;[4] and the details need not be repeated here.

10. *Lake Valley Limestone.*—The geologic age of this Early Carboniferous formation was first determined in 1881, by Mr. S. A. Miller[5] from fossils collected by Prof. E. D. Cope, of Philadelphia, who was at that time President of three of the Lake Valley mining companies. More extensive collections of fossils were made several years later by Mr. Frank Springer,[6] who recognized the fauna as corresponding to that of the Lower Burlington limestone of Iowa, a formation which has been, of late, widely recognized in New Mexico.[7]

At Lake Valley this formation is 150 ft. thick, and consists chiefly of more or less shaly and highly fossiliferous limestones.

[4] *Proceedings of the Iowa Academy of Sciences*, vol. xiii., pp. 197, 198 (1906).

[5] *Journal of the Cincinnati Society of Natural History*, vol. iv., pp. 306 to 315 (1881).

[6] *American Journal of Science*, Third Series, vol. xxvii., p. 102 (1884).

[7] *Proceedings of the Iowa Academy of Sciences*, vol. xii., pp. 169 to 171 (1904).

The Early Carboniferous rocks of New Mexico are regarded as belonging to the Socorran series,[8] corresponding to the Mississippian series of the Interior Basin region.

11. *Sierra Limestone.*—The uppermost member of the clastic series at Lake Valley differs very materially from all other terranes in being a gray, compact, massively bedded lime-rock, of distinctly coralline character, yet exhibiting but few well-preserved organic remains. The fossils thus far found in this upper limestone suggest strongly the fauna of the Upper Burlington and Lower Keokuk limestones of the Mississippi valley. The formation has an exposed thickness of about 50 ft.

VI. Unconformities.

The Lake Valley section includes three horizons at which occur marked breaks in the sedimentation. All three of these planes display discordance between the strata, and hence represent periods of erosion. While these have no doubt affected the ore-deposits of Lake Valley, they have had, in the neighboring districts, a much greater influence upon the distribution of the ores.

The most marked plane of unconformity is at the base of the black Silver shales. The direct effects of this pre-Devonian erosion were far-reaching. Over most of the region the Silurian rocks, together with much of the Ordovician formations, were entirely removed. In some places, however, remnants of the Silurian were preserved.

A second unconformity occurs at the base of the Carboniferous limestones. The evidence of this discordance in sedimentation is not so apparent at Lake Valley as elsewhere in southwestern New Mexico. Nevertheless, the shales beneath the Blue limestone have been, in many instances, entirely removed, so that this lime-rock rests directly upon Silurian or Ordovician limestones of similar lithologic character.

The third marked unconformity is shown by the eruptive rocks lying upon the beveled edges of the sedimentaries. In connection with these, some later clastic formations also occur.

[8] *Journal of Geology*, vol. xiv., p. 151 (1906).

VII. Geologic Structure.

1. *Main Characteristics.*—Viewed in its entirety, the tectonic aspect of the Lake Valley district is that of a monoclinal block tilted about 20 deg. southeastward, in which mass, thus disturbed, differential weathering has made deep valleys of the non-resistant formations, and long, sharp, parallel ridges of the hard beds, as explained above. This structure is diagrammatically represented by the cross-section shown in Fig. 2.

2. *Folding.*—Prior to the period of the Berenda faulting, which produced the main monoclinal block, the most notable structural feature was a series of gentle folds. This undulatory character of the strata is still plainly preserved, in spite of frequent subsequent faultings and other marked deformations. The direction of the compressive forces was northeast and southwest.

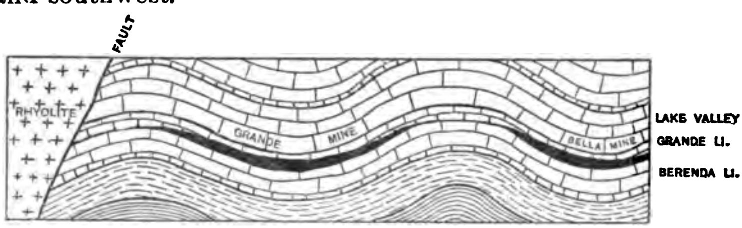

Fig. 2.—Cross-Section of Synclines, with Ore-Bodies in Bottoms.

In the subsequent southeastward tilting to which the beds were subjected, the inclination was in the direction of the axes of the great corrugations. It was in the pitching synclines that the principal ore-bodies of the district were deposited. A transverse section of the chief ore-producing field is shown by the diagram, Fig. 3, in which the later minor faulting has not been taken into account.

These inclined beds have been slightly folded, faulted in at least three different directions, repeatedly broken through by eruptives, and covered by lava-flows.

3. *Faultings.*—The recognition of extensive stratigraphic dislocation in the Lake Valley district is very recent. Clark,[9] in his description of the mine-workings, explained everything in the way of geologic structure by postulating the existence of folds. Only in two isolated instances did he even suggest

[9] *Trans.*, xxiv., 138 to 167 (1894).

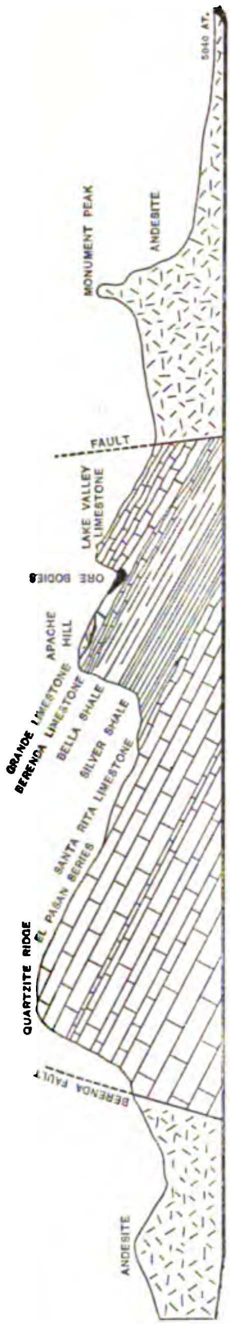

FIG. 3.—GEOLOGIC CROSS-SECTION OF LAKE VALLEY DISTRICT.

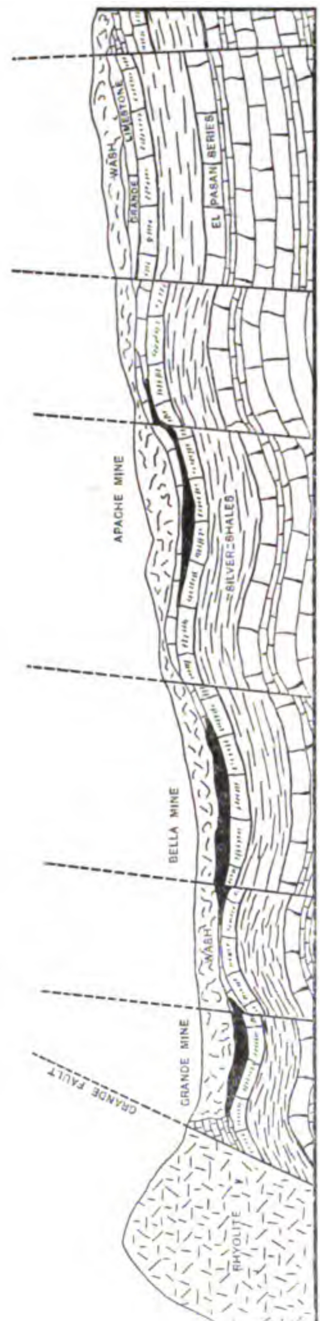

FIG. 5.—CROSS-SECTION OF GRANDE-BELLA-APACHE ORE-BODIES, SHOWING FAULTING.

the presence of faults; and these were regarded as of such small consequence as to require no explanation whatever.

Mr. Clark's account of the district contains much of value, and his descriptions of the developments are very complete, but his geologic observations are not equally clear. From his map, the real geologic structures are very hard to understand, and many representations are impossible. Frequent faulting, the evidence of which is plainly discernible on the surface, he has entirely neglected. In fact, the three most important and fundamental features, directly bearing upon the deposition of the ore-bodies and the formation of the ores themselves, have been wholly overlooked.

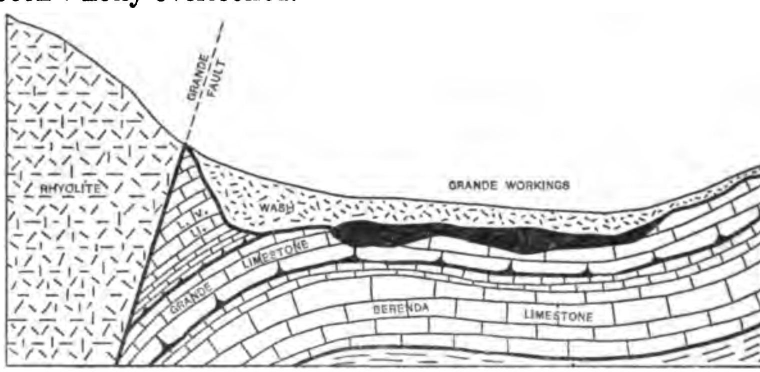

FIG. 4.—DETAILS OF THE GRANDE FAULT.

In the Lake Valley area, there have been three distinct periods of faulting, resulting in three series of faults. The first has a northwesterly and southeasterly strike, at a considerable angle to the axes of the folds already described. The second courses are nearly at right angles to the first—namely, northeast and southwest. The third series, of minor, close-spaced faults, strikes due east and west.

The first-mentioned, or "Grande" fault, brings the early rhyolitic outflow down against the Paleozoic strata, cutting them off sharply. This line of dislocation passes through the Sierra Grande property and limits all exploratory work to the south. The throw of the fault has not been determined; but the indications are that it is not less than 1,000 ft. It hades about 15° south. Details of the dislocation as shown in the main workings are represented in Fig. 4. This fault appears to ante-date, by a long interval, the Berenda slip.

The second period of profound dislocation is represented by the Berenda fault, producing the Berenda valley, the Quartzite ridge and other marked features of the local topography. It appears probable that a parallel fault of minor importance lies on the west side of Apache hill, and that the long valley here is not due wholly to differential weathering. Still another parallel fault of great extent lies to the west of Monument peak, bringing the andesite flows and the Carboniferous limestones into juxtaposition. A minor fault of the same series may also exist between the Apache hill fault and the one last mentioned. The displacement of the Berenda fault is more than 800 ft.; that of the Monument peak fault at least 300 ft.

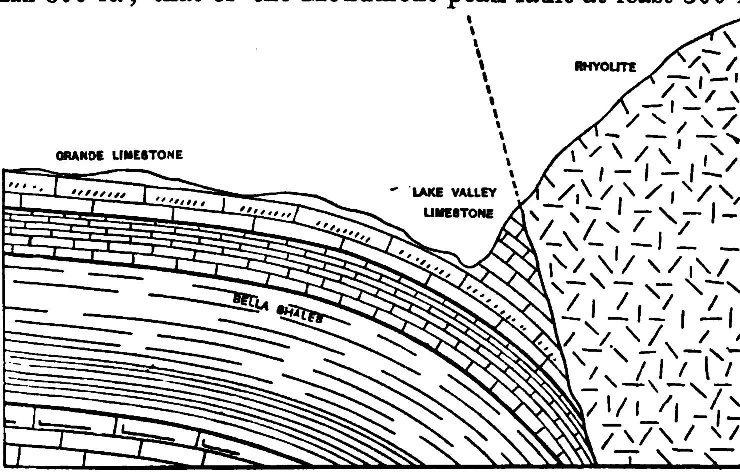

FIG. 6.—JUNCTION OF RHYOLITE AND LIMESTONE AT THE GRANDE FAULT.

In the faults of the third series the throw is nowhere great; probably in none of them does it exceed 100 ft. Nearly a score of distinct slips of this series, all of them trending east and west, and in most of them plainly traceable on the surface for a greater or less distance, have been recognized within a mile. They directly affect the ore-bodies in a remarkable way. A cross-section through the main workings is represented in Fig. 5.

4. *Relations of the Eruptives.*—The earlier, or rhyolitic, eruptive mass may have been laccolitic in character, rather than a simple surface-flow, with Lufkin mountain as a center. Through the Grande fault the northern side of the main rhyolitic mass abuts directly against the Paleozoic limestones, the

line of junction being nearly a straight line (see Fig. 1). The relations of the two rock-masses are shown in the accompanying sketch (Fig. 6).

The later, or andesitic, eruptive masses are manifestly surface-flows of lava, rather thin in places, but at Monument peak at least 400 ft. thick. They appear to have covered the entire surrounding area, except Lufkin mountain. That the limestones were completely covered, is shown by remnants of considerable size which lie upon the highest parts of Apache hill and other neighboring elevations. The relations of the Apache area of andesite to the underlying limestones are indicated in Fig. 7.

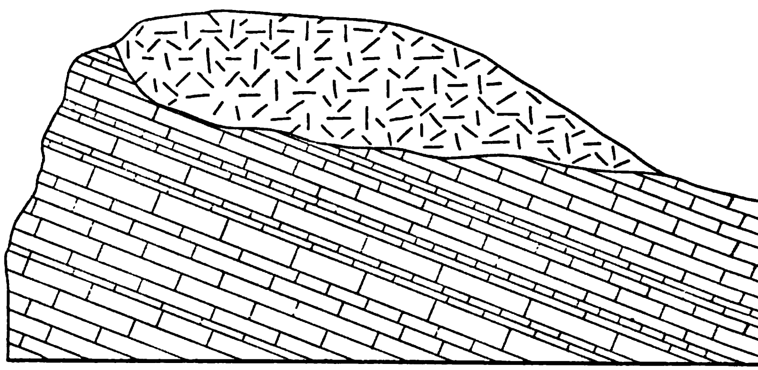

FIG. 7.—RELATIONS OF ANDESITE AND LIMESTONES ON CREST OF APACHE HILL.

VIII. GEOLOGIC RELATIONS OF THE ORE-BODIES.

1. *Governing Factors.*—The dependence of ore-deposition upon local geologic conditions is illuminated in a remarkable manner in the Lake Valley district. The ore-bodies are strictly confined to a limited geologic horizon; they are associated with a distinct lithologic zone; they are segregated in well-defined pitching troughs; they present definite relations to certain topographic features; and they are sharply delimited with reference to antecedent faulting.

These several features could be made the basis of an extended and highly suggestive discussion; but in the present connection they can be only touched upon.

2. *Position.*—All the ore-deposits are definitely situated in the local geologic column, being confined to the Grande, or Blue, limestone, which is only 25 ft. thick. On the whole, this

lime-rock is very pure, fine-grained, and easily soluble; hence, it is readily made cavernous.

In the field the Grande limestone is sharply demarcated. Immediately below it, the nodular Berenda limestone is readily distinguishable wherever encountered. Above it, the Lake Valley shaly limestone cannot be mistaken. Both of these formations have manifestly exerted an important influence upon the confinement of the ore-bearing waters to the Blue layer.

3. *Relations to Foldings.*—As already intimated, all the ore-bodies are very definitely associated with the broader corrugations of the older stratified beds in which they occur. The ore-materials have been segregated in the shallow synclines, which now pitch at an angle of about 20°. It is believed that these troughs were primarily involved in the accumulation of the ores.

It is difficult to determine just how far the localization of the ores has been due to the synclinal structure, and how far to the impounding tendencies, below ground-water level, of certain of the major faultings. The latter factor is probably the more important; but the suggestiveness of the former cannot be overlooked. The relative effectiveness of the two may be estimated by comparing the amounts and the proportional richness of the ores available at the north and south ends of the mining belt respectively. Towards the north end the main deposition of the metalliferous deposits is still clearly in the troughs, with only slight amounts on the crests of the arches. The ratio of the amount of metal from this part of the belt, as compared with that of the south end, where the impounding has been most pronounced, is about as 1 to 4.

The marked influence of shallow synclinal structure in the localization of workable ore-bodies has been noted in many other mining regions; and the recognition and determination of these features at Lake Valley should be made a directing factor in exploratory work.

4. *Relations to Lines of Dislocation.*—At first glance it would appear that faulting had disturbed and broken the main ore-bodies; and this seems to be the opinion prevalent among the miners. Closer inspection, however, shows clearly that this is really not the case. On the contrary, it is manifest that even

the latest movements of the rock-masses, represented by the minor east-and-west series of faults, were all produced before the ores were segregated in their present position. As a rule, the amount of displacement is not great enough to separate very far the ends of the ore-bearing Blue limestone, or to prevent the cavernous zone from being continuous, though it may, perhaps, be greatly reduced in thickness along the planes of slipping.

That the last period of faulting took place prior to the concentration or accumulation of the ore-bodies in the present positions is clearly demonstrated by the abrupt, straight walls limiting them along the lines of rock-movement. If the faulting had taken place subsequent to the ore-deposition, the ore-bodies themselves would be faulted; and evidence of this is nowhere apparent.

The only effect of the Grande fault at the south end of the ore-belt has been relatively to raise the hard, impervious rhyolite above the level of the cavernous Blue limestone (which is also inclined towards the fault), and thus to impound the underground waters in the zone where the ores have gathered. It is noteworthy that no ores have remained above the level of the impounded waters, as determined by the outflow over the present surface at the lowest point on the fault-line.

So far, then, as concerns any effect upon the ore-bodies after their formation, the faults may be disregarded in all mining operations within this district.

5. *Relations to Present Surface-Relief.*—The relation between ore-bodies and the local topography is so obvious that more than ordinary stress may be placed upon the existing surface-conditions. It is seldom that any dependence of the formation of ore-bodies upon the local topography can be recognized. But, to the contrary, Lake Valley presents an exceptionally interesting instance, suggesting, indeed, a possible genetic inter-relationship of ore-deposits, commonly overlooked hitherto.

On the assumption that the principal mineralization of the district occurred at the time of the great rhyolitic eruptions, when the limestones were lying flat, or nearly so, there appears to have been, after the main tilting, a gradual migration of the ore-materials of the Blue limestone down the slope and a gradual enrichment, until the present location was reached.

The ore-bodies manifestly remained near the surface, but about at permanent water-level, and were covered only by the clayey limestones of the Lake Valley formation. The ridge formed by the last-mentioned terrane migrated eastward more than 2 miles to its present position. During the long period of this movement and wearing-away it served as part of a dam, as it were, which impounded the ore-bearing waters. The zone of maximum ore-deposition, therefore, advanced closely upon the constantly moving ridge.

The conditions above described remained constant until quite recently. As the great impounding ridge continued to change its position to the eastward it finally met, at its present location, the headwater erosion-lines of east-directed drainage-ways. These have cut the barrier ridge at three points, making channels through which impounded underground waters are drained eastward (instead of southward through the former overflow-point on the Grande fault-line, where the rhyolite and limestone juncture is lowest). The new drainage has not yet progressed far enough to permit the full outflow of waters down to the level of the present base of the ore-bodies; but it has been sufficient to remove the greater part of the original mass of ore. Probably nine-tenths of the former ore-mass had been already removed in this manner before man, by more rapid means, began to take away his remaining one-tenth.

Extensive exploratory work beneath the ridge of the Lake Valley formation clearly shows that ore-deposition does not extend very far beyond the margin of the clayey limestone already referred to, or the basset edges of the basal layer of that formation, as it rests on the Blue limestone beneath.

The relation of the ore-belt to the eroded edge of the Lake Valley limestone is more clearly displayed in Fig. 8.

6. *Relations to Eruptive Rocks.*—So far as observable, the ore-bodies are now in no way directly connected with the numerous eruptive masses of the region. The original contact-mineralization, near the present Berenda fault, is 2 miles away from the ore-belt. This appears to be the nearest point of direct metamorphic action.

Clark,[10] in his description of the mines, makes much of a

[10] *Trans.*, xxiv., 138 to 167 (1894).

so-called "porphyrite" overlying the ore-bodies, as the source of the ore-deposition, or as greatly influencing it. Careful examination, recently made, seems to indicate pretty conclusively that the so-called porphyrite is not an eruptive, but an accumulation of rock-waste, having lime as a large factor in the cementing material. In that case the "porphyrite" could have had no influence whatever on the formation and localization of the ores.

7. *Relations to Lithologic Nature of Country-Rock.*—That the ore-materials have been confined to a rock-stratum of distinctive character is doubtless due, partly, to the peculiar lithologic

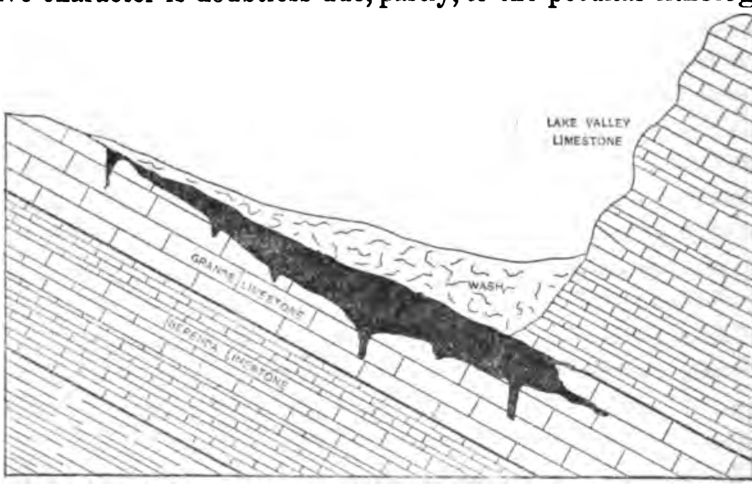

Fig. 8.—Relations of Ore-Body to Basset Edges of Lake Valley Limestone.

nature of that stratum. The selective tendency of the Blue limestone may be ascribed to a number of features. By reason of its pure calcareous character, it is liable to become cavernous; and, in connection with this condition, it is quite likely that the hydrocarbons and organic matter contained in the limestones had much to do with the reduction of the metalliferous salts in the circulating waters, and thus with the localization of the deposits.

IX. Mineralogic Character of the Ores.

The silver-ores of Lake Valley are black in color, crystalline to earthy in texture, and easily treated. They consist largely of ferric and manganic oxides, through which the other metal-

lic minerals are scattered. There is very little gangue. The iron and manganese obscure everything else contained in the deposits, and also cover the upper surface of the Blue limestone, wherever it is exposed, for a long distance beyond the margins of the workable ore-bodies.

The silver-values are chiefly in the form of cerargyrite (silver chloride), argentite, and argentiferous galena. There are also smaller quantities of other silver-ores: embolite (silver chloro-bromide), proustite (arsenious silver sulphide), and stephanite (antimonious silver sulphide). Beautiful crystals of cerargyrite occur—perfectly formed cubes about 1 mm. in size.

The fact that in the reduction-works large roasters were installed suggests that the sulphides were present in much larger proportion than casual inspection would indicate.

Other interesting mineralogical occurrences are certain vanadium compounds, and pyrolusite in beautiful crystals, botryoidal and reniform masses.

There are probably considerable amounts of carbonate ores of lead, and possibly zinc, present in the ores; but, if so, they are entirely disguised by the ferruginous minerals.

X. Origin of the Ore-Deposits.

1. *General Statement.*—The ores of the Lake Valley may be, for all practical purposes, classed as silver-chloride deposits. By far the larger proportion of the great production was of this nature. Considerable amounts of the chloro-bromide (embolite) were also mined. The formation of this class of ores in large amount is of exceptional interest, because the process finds its most favorable conditions in arid and semi-arid regions. Other climatic conditions do not permit results permanent enough to be advantageously investigated. The presence of sulphides in these deposits is suggestive. They are most abundant towards the bottoms of the ore-chambers. In the early days of mining, the carbonates of lead and zinc are said to have been abundant.

The origin of the Lake Valley ore-deposits has been the subject of wide discussion. The earliest opinion attributed the deposits directly to ascending currents of warm waters, carrying the metalliferous salts in minute quantities. A later view ascribes the ore-bodies to the leaching of an overlying "porphy-

rite," which was assumed to be silver-bearing. Other opinions have been expressed from time to time. None of these various hypotheses appear to be confirmed by the more recent examinations. In fact, all the data obtained militate strongly against these views, and indicate almost conclusively a different mode of formation.

2. *Original Source of the Ore-Materials.*—No true fissure-veins are yet known in the ore-belt, or in any part of the country for several miles around. The eruptive masses which have broken through the sedimentaries in late Tertiary and Quaternary times have extensively mineralized the beds with which they have come in contact. Neighboring districts display this phenomenon much more clearly than Lake Valley. In some of them, the mineralization extends into the clastic rocks at least 500 or 600 ft. Some of the metalliferous contact-zones are sufficiently rich in silver sulphides and argentiferous galena (both very finely divided and disseminated) to form workable bodies.

There is also good reason for believing that, before the rhyolites and andesites broke through, and while the limestones were yet lying flat or nearly so, the Blue limestone was already a lean ore-horizon carrying lead and zinc, with perhaps a little silver. It may even be that workable deposits of galena existed thus early in the shallow synclines which were already a feature of the geologic structure.

The principal contact-zone appears to have been near the Berenda fault-line, about 2 miles west of the present ore-belt and parallel to it. All the limestone of this part of the area seems to be very much more metamorphosed and mineralized than ordinarily would be expected, and much more than are the limestones of the same age elsewhere in the neighborhood.

The great rhyolitic mass of Lufkin mountain, which cuts off the ore-belt at the south, shows no evidences of metamorphic action at its juncture with the clastics.

Remnants of thin andesitic flows are found near the summit of Apache hill, above the ore-belt, about 500 ft. vertically higher than the top of the ore-bodies. These surface-flows of acidic lava carry minerals of silver, lead and other metals in small quantity. Since they once covered probably the whole district before the valleys were eroded to their present depths,

considerable amounts of mineral may have been furnished by the decomposition of the lava sheets.

In the main, the supplies of ore materials are believed to have come originally from the contact-veins, but to have been concentrated and enriched under unusual conditions, by means of which the final deposits were so far removed from their former position that, at first glance, no connection between the two would be suspected.

3. *Contact-Metamorphism of the Region.*—Little need be said here concerning the contact-phenomena, since these are now but remotely and indirectly associated with the existing ore-bodies. The latter, as remarked above, are now fully 2 miles from the probable main contact-zone, from which their materials were mainly derived. It is not improbable that the contact-influences extended laterally along certain stratigraphic horizons. In New Mexico it is everywhere apparent that the mineralizing effects of contact-metamorphism extend much further from the plane of contact than has been generally suspected.

As a rule, students of petrography have greatly underestimated the potency of contact-metamorphic action in connection with ore-deposits. They have been content with a contact-alteration zone of a few inches or a few feet, and have placed the greatest stress upon the effects of regional metamorphism. This circumstance is doubtless due largely to the fact that most of the more exhaustive petrographic investigations relating to this subject have chanced to be in localities in which regional metamorphism has been most in evidence, and contact-metamorphism has produced minimum effects.

In New Mexico, and the Southwest generally, and, perhaps, throughout the Mexican plateau and Great Basin regions also, the effects of regional metamorphism are practically *nil*. Contact-metamorphism only is encountered; and, being unobscured by regional metamorphic effects, it can be investigated by itself.

In the presence of so clear a display of contact-metamorphism, many of our older notions of this phenomenon are likely to undergo radical change. Instead of a simple mineralogical rearrangement of component particles, through a very limited zone bordering the contact, according to the con-

sensus of opinion heretofore, we find an extensive transference of new materials into the wall-rocks. In the sedimentary rocks, this introduction of extraneous material may reach into the walls hundreds and even thousands of feet, instead of only a few feet or even inches as a maximum. Moreover, some layers are much more affected than others; so that, for instance, in a given limestone series, the transference of even metalliferous particles may extend, in some layers, for a mile or two from the contact-plane, while in adjoining layers appreciable changes may not extend more than a few hundred feet, and in still others, not more than a few inches.

4. *Process of Ore-Concentration.*—Segregation and enrichment at the bottom of the oxidized zone probably took place in the Lake Valley deposits in the same way as in ordinary steeply dipping veins. But this instance is peculiar, in that, after general degradation of the area had gone on for a considerable period, the limestones were disturbed and tilted at a high angle, and, as the permanent water-level was gradually lowered with the progress of general erosion, the enriched ore-bodies, through oxidation, solution and reprecipitation as sulphides, changed their positions laterally as well as downward. In other words, they migrated, as it were, down the slope of an inclined layer of cavernous limestone, until finally they became entirely separated from the original contact-vein. A number of similar cases could be cited from neighboring districts.

The influence of geologic structure and of special features of surface-relief in bringing about this result has been already discussed.

The geologic conditions which have so long conspired to preserve the Lake Valley ore-deposits are now fast changing; and soon every trace of the original ore-belt will have been obliterated. Such inroads have been made upon the peculiar topographic feature which has served to impound the waters hitherto, that it may not be very long before the ore-zone will be drained above ground instead of underground.

The present remaining mass of the ore-deposits is but a fraction of the former aggregate, yet from this remnant millions of dollars have been realized.

5. *Lowering of Ground-Water Level.*—This district presents evidences of recent, notable and repeated changes in the

ground-water level—a phenomenon more frequent than is generally supposed, but accompanied, in this instance, with an unusually clear exhibition of the causes producing such changes.

The extent of the most recent lowering of the water-level exceeded 1000 ft. So far as the ore-bodies are concerned, this lowering has kept in advance of the general degradation of the district. At the present time, a point has been reached in which the local erosion has just overtaken the lowering of the underground-water level, and now threatens the complete effacement of the ore-deposits.

Change in the ground-water level has not been always downward; there have been also slight upward movements. It is to this oscillation of the water-level that certain otherwise inexplicable features of the gossan-zone are to be ascribed. A general discussion of the phenomenon comes more properly in another place.

6. *Formation of Cerargyritic Ores.*—The prevalence of chloride-ores in the weathered zone of the silver-deposits of New Mexico is of great interest. A fundamental influence upon both the formation and the preservation of large amounts of ores of this class appears to have been exerted by the dryness of the New Mexican climate, and by the presence of an abundance of chlorides in the circulating waters of the weathered zone of this region, as facilitating the decomposition, transference, and re-deposition of ore-materials, in both silver- and gold-veins. This region affords an exceptionally favorable opportunity for an exhaustive study of the transformations of the chloride ores generally.

The genesis of the cerargyritic ores has long been a theme of speculation. No hypothesis yet advanced can be made to cover all deposits of this class. They have, in fact, several distinct modes of origin; and the processes and conditions in one region may find no counterpart in those of another. The following hypotheses as to the formation of cerargyrite deserve mention here:

(1) The chloridization may have been due to small quantities of salt dissolved in the circulating ground-waters. This general proposition, early advanced by Bischof,[11] while it has

[11] *Lehrbuch der Chemischen und Physikalischen Geologie*, vol. iii., p. 808 (1866).

been accepted for a large number of localities, is purely theoretical and very primitive. It does not account for the presence of the chloride compounds in the circulating waters—which is, from a practical standpoint, all-important.

(2) The chloride-ores have been formed by the action of weak saline solutions on the native metals. This phenomenon is frequently observed in many mines of the American arid regions, where a thin crust of horn-silver is often found covering a mass of native silver. Silver vessels from excavations of ancient cities are often coated with the chloride, as has been fully described by Schertel[12] and others. Old silver coins, unearthed, frequently show such a surface-change. In nature, however, this process can hardly have been an important factor in the production of chloride-ores in large quantity.

(3) Chloride-ores may have been produced by the action of sea-water on vein outcrops, as urged by Mösta[13] for the silver chlorides of Chile. Of similar import are Brauns's[14] observations of the action of sea-water on the slag-heaps of the Laurion lead-district of Greece. Other examples might be mentioned. But cases of this kind must be at best isolated and exceptional.

(4) Such ores may be due to the direct action of waters from saline lakes. This mode of formation has been emphasized by Penrose,[15] in accounting for the production of horn-silver in the desert regions of western America; and the same idea, though differing somewhat in details, is expressed by Spurr[16] regarding some of the Nevada silver-ores. Another modification of the same suggestion is that of Ochsenius,[17] who postulates upraised lagoons, afterwards draining into the silver-deposits below. This explanation is also given by Sandberger[18] for certain Peruvian ore-deposits, particularly those of the Cerro de Huantajaya.

The existence of former Quaternary and Tertiary lakes in many parts of the Great Basin region, as a direct means of

[12] *Journal für Praktische Chemie*, vol. iii., pp. 317 to 319 (1871).
[13] *Vorkommen der Chlor- Brom- u. Jodverbendungen des Silbers* (1870).
[14] *Chemische Mineralogie*, p. 367 (1896).
[15] *Journal of Geology*, vol. ii., p. 314 (1894).
[16] *Geology Applied to Mining*, p. 286, New York (1904).
[17] *Die Bildungen der Natronsalpeters aus Mutterlaugensalzen*, p. 51, Stuttgart (1887).
[18] *Neues Jahrbuch für Mineralogie, Geologie und Paleontologie*, p. 174 (1874).

changing the ores of the gossan beneath into chloride form, as urged by Penrose, seems to me to be a wholly untenable assumption. Cerargyrite ores are usually found in the mountains, far above the highest level of any of these old lakes. These mountain-ores are the only ones thus far exploited. Chloride deposits, if they exist at all beneath the old lake basins, remain to be discovered. It cannot be assumed that saline lakes formerly existed above the mountain-ores, nor that the rock-masses of the mountains have all been upturned and uplifted since the lakes ceased to exist. It is true that some of the Tertiary lake-beds, 3,000 or 4,000 ft. in thickness (as, for instance, those of the Funeral range in southeastern California), have been tilted and raised to even greater heights; but cerargyrite ores do not appear to be particularly plentiful in any of these localities.

(5) The chloridizing agents may have been derived from saline materials liberated by the weathering of rocks, as incidentally suggested by Beck.[19] Spurr[20] also mentions this hypothesis, especially in connection with the deposits of Nevada. This source of suitable chlorides for the metals is much more important in humid than in arid districts. In the American Southwest its contribution must be inappreciable.

(6) The formation of metallic chlorides may have been aided by the deposition of dust, blown from the sea-coast. This is mentioned, as a possible co-operative agency, by Beck.[21]

(7) The necessary chloridizing compounds may have been furnished by the evaporation of ground-waters in an arid climate, leaving a saline deposit near the surface of the soil. In a similar way lime-salts are extensively formed throughout dry regions, a foot or two beneath the surface, producing a deposit easily mistaken for limestone, and termed *caliche* by the Mexicans.

(8) Chlorine may have been contributed through direct volcanic activity, either by emanations of free chlorine, as in the cases of many modern volcanoes, such as Vesuvius and Cotopaxi (the latter especially noted by Wolf[22]), or by emanations

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[19] *The Nature of Ore-Deposits* (Weed's translation), vol. ii., p. 375 (1905).

[20] *Geology Applied to Mining*, p. 286, New York (1904).

[21] *Loc. cit.*

[22] *Neues Jahrbuch für Mineralogie, Geologie und Paleontologie*, p. 164 (1878).

from dry fumaroles during the period of most energetic activity, when the temperatures are very high and anhydrous chlorides of various kinds are given off in great abundance, as described by Sainte-Claire Deville[23] and others. Such chlorides may accumulate between layers of lava, as in the cases cited by Geikie[24] of the old volcanoes of Scotland.

(9) Through the agency of wind-blown saline dust (not necessarily from the sea-coast), which is distributed in large quantities throughout the arid regions.

In the Southwest of this country the chlorides, which have produced metallic ores, are not thought to be directly due to volcanic activity. Notwithstanding the vast outpourings of eruptives in the region, the period of the latest of these is manifestly too remote. Although it is well known that in many volcanic regions great amounts of the more common chlorides are often interbedded with the ordinary lava sheets, as just stated, yet, in the region under consideration, general erosion has taken place to such an extent that this source cannot be looked to for an adequate supply of such chlorides.

The most likely source of sufficient supplies of chlorides to act upon the metalliferous deposits of the region is, therefore, the air. This hypothesis, the last of those enumerated above, suggests the cause which has acted most effectively of all in the Lake Valley district, and probably throughout the dry desert regions generally, though not to the total exclusion of others.

The supplies of saline materials could easily be, and no doubt mainly were, wind-borne. The dusts of New Mexico always contain appreciable quantities of saline particles. Dust-storms are violent and frequent. While they last, the atmosphere is so filled with fine soil that it is impossible to see more than short distances. Ephemeral pond-waters, in drying up, often leave a white coating on the ground that is popularly termed "alkali." In reality, the white precipitate is composed very largely of common salt.

The amount of saline material in the dusts of New Mexico is a constant factor. The quantity of salty matter furnished

[23] *Annales de Chimie et de Physique*, Third Series, vol. lii., p. 19 (1858).

[24] *Proceedings of the Royal Society of Edinburgh*, vol. ix., pp. 367 to 371 (1875–8).

by this means very greatly exceeds, for a given area, that supplied by the decomposition of the rocks. When the rock-layers are highly inclined, as they are in most of the basin ranges, the saline matter in the dust deposited on the surface is easily dissolved by the first rain, and largely carried below, to mingle with the underground waters.

The introduction of measurable amounts of saline material into the ground-water manifestly supplies one of the most favorable conditions for the formation of haloid compounds of the metals. Another favorable condition is a geologic structure which promotes the impounding of meteoric waters underground; and a third is such a peculiar surface-contour as aids in gathering saline materials, retaining them in the surface-waters, and preventing them from passing off before they have opportunity to be included in the waters underground. In the Lake Valley and neighboring districts, all of these conditions combine in high degree to the production of abnormally large amounts of saline matter in the waters circulating through the gossan.

Other haloid compounds of the metals are also found in the Lake Valley deposits. The chloro-bromide of silver, embolite, occurs in sufficient abundance to form an important percentage of the ores mined. Were it not for the large amounts of manganese and iron oxides which make the entire ore-body appear to consist merely of ores of those metals, it is probable that other haloid minerals would be recognized in greater or less abundance. Several such minerals are known to occur in neighboring districts, where their presence is not obscured by these dark-colored materials. The bromide and the iodide of silver (bromyrite and iodyrite) are instances; the chlorides of lead and of copper may also be present. A careful inquiry into the mineralogy of these ore-bodies would prove highly instructive.

No native silver has been reported to occur at Lake Valley; yet this does not preclude its occurrence in considerable quantity. In the neighboring districts, under similar conditions (except that the associated manganese and iron oxides are not so abundant), large amounts of native silver are found. It may be suggested that the cerargyrite has been derived from such native silver, as has been found to be the case elsewhere (and is, indeed, probable in an instance only a few miles away); but

the shallowness of the Lake Valley deposits, their position near permanent water-level, with only a few feet of wash above, and the presence of abundant sulphides in the deeper parts of the deposit, preclude this supposition.

On the other hand, the presence of sulphides, the thinness of the deposit (which may be regarded as a "blanket-vein"), the character of the local relief and geologic structure, both of which are especially fitted for the purposes of collecting and retaining meteoric waters, indicate that the cerargyrite was formed directly from sulphates, produced by the oxidation of the sulphides (argentite, stephanite, and perhaps also silver-bearing galena).

In a steeply-dipping vein, the migration of ore-material downward through the oxidized zone is well known. It is also often the case with cerargyrite, the richest ore-bodies of which are frequently found near ground-water level, or immediately above the sulphides. In other instances, such as those described by Mösta,[25] in Chile, there appear to be several distinct zones in which cerargyrite occurs. In general, the downward journey of the chloride ores in such veins is not difficult to follow; but the Lake Valley deposits in this downward journey have been, after a while, chiefly diverted down a steep and open stratigraphic plane, instead of the line of the original vertical contact.

XI. Recapitulation.

The most suggestive features brought out in the foregoing discussion may be briefly summed up. In the Lake Valley district it appears that:

a. The original source of the ores was in extensive contact-mineralization.

b. The ore-deposits have definite relations with the geologic structure of the district.

c. The ore-deposits are also fundamentally dependent upon peculiarities of the local surface-relief.

d. The ore-deposition has shown a marked preference for certain rock-layers.

e. The ore-deposits have now no direct association with any of the numerous eruptive masses of the region.

[25] *Vorkommen des Chlor- Brom- u. Jodverbindungen des Silbers* (1870).

f. The ore-deposits have not been faulted to any appreciable extent.

g. There has been marked oscillation in the ground-water level.

h. The usual explanations of the origin of haloid ores are of very limited application, and probably do not obtain at all in the southwestern United States.

i. The main source of the chlorides producing the cerargyritic ores has been the saline dusts of the arid regions.

j. In the arid regions eolian agencies predominate among the geologic factors, while in humid regions aqueous agencies are most effective.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Evergreen Copper-Deposit, Colorado.

BY ETIENNE A. RITTER, COLORADO SPRINGS, COLO.

(Toronto Meeting, July, 1907.)

INTRODUCTION.

THE Evergreen mine, located at Apex, in the northern part of Gilpin county, Colorado, has opened a very peculiar and interesting copper-deposit, in which both bornite and chalcopyrite occur as rock-minerals.

The country-rocks are crystalline schists cut by dikes of granulite and of pegmatite. At the Evergreen property they have been cut by a dike of a new kind of eruptive rock, to which I have given the name "Evergreenite." The rock is composed of quartz, alkali feldspars, orthoclase and albite (often interlocked as microperthite), with augite of the ægirine variety and long needles of enstatite and diallage. For reasons stated below, I believe the dike to be of Tertiary age. It is easily traced on the surface of the ground, from a point in the bottom of Pine creek, about a mile below Apex, to the top of Nevada hill, 1,500 ft. beyond and 600 ft. above it. (See Fig. 1.) It varies from 3 to 12 ft. in width, and is bounded on both sides by contact-zones about 60 ft. wide, in which the crystalline schists have been changed into pseudo-quartzites or pseudo-gneisses, according to the injection of an excess of quartz or of feldspars through the special layer of the schists. The most interesting feature is the presence of the pyroxenes, which are always found, though in very variable proportions from place to place, in the layers of these metamorphosed crystalline schists.

The dike has torn from its walls a large number of fragments of the wall-rock. It must have been in a viscous state when that happened, because these fragments of the wall-rock do not show any sign of resorption or of assimilation by the magma. In places they are so distinct and so numerous that the rock looks to the naked eye like a pseudo-breccia, of which, never-

theless, the true nature is easily recognized in the microscopic slides. The most striking feature is the great difference in freshness between the eruptive rock and the inclosed fragments of the wall-rock. The former is marvelously fresh. It does not show any decomposition-products. The feldspars of the inclosed pieces of wall-rock, on the contrary, are completely changed into sericite; but the biotite is fresh yet. There has been a strong sericitization, but no propylitization.

The dike-rock shows microscopic structures, which, in many places, blend into one another, but may be quite distinct at other places. These structures are granulitic, with a tendency to become micropegmatitic and porphyritic.

A large proportion of the ore is found in the dike itself, in which chalcopyrite and bornite appear as rock-minerals, to the same degree as the quartz, the feldspars or the pyroxenes. Fig. 2 clearly shows this occurrence. These copper sulphides must have come up dissolved in the magma at the time of its ascent to form the dike, and must have crystallized together with the silicates of the eruptive rock. It is a striking example of the deposition by sublimation, under pneumatolytic action, so ably and completely worked out by Elie de Beaumont, Henry Sainte-Claire Deville and Daubrée, towards the middle of the last century. Since then it has been shown that deposits of this kind are the rare exceptions. But they are very important in throwing a great deal of light on the way the majority of the ores can come from great depths to within a distance of the surface small enough to allow the circulating waters to dissolve them and to bring them up in the veins.

I do not know of any other copper-deposit in which the genesis of the ore, as a rock-mineral, segregated in the cooling of the eruptive magma, is so plain and can be so well illustrated by the study of microscopic slides. The proposition that bornite is a rock-mineral is not new. It has been already proved by Prof. J. F. Kemp[1] and Jules Catherinet[2] in a pegmatite dike in the Similkameen district, B. C.

The view that some copper-deposits may have been formed by segregation from a magma has always been held in Europe,

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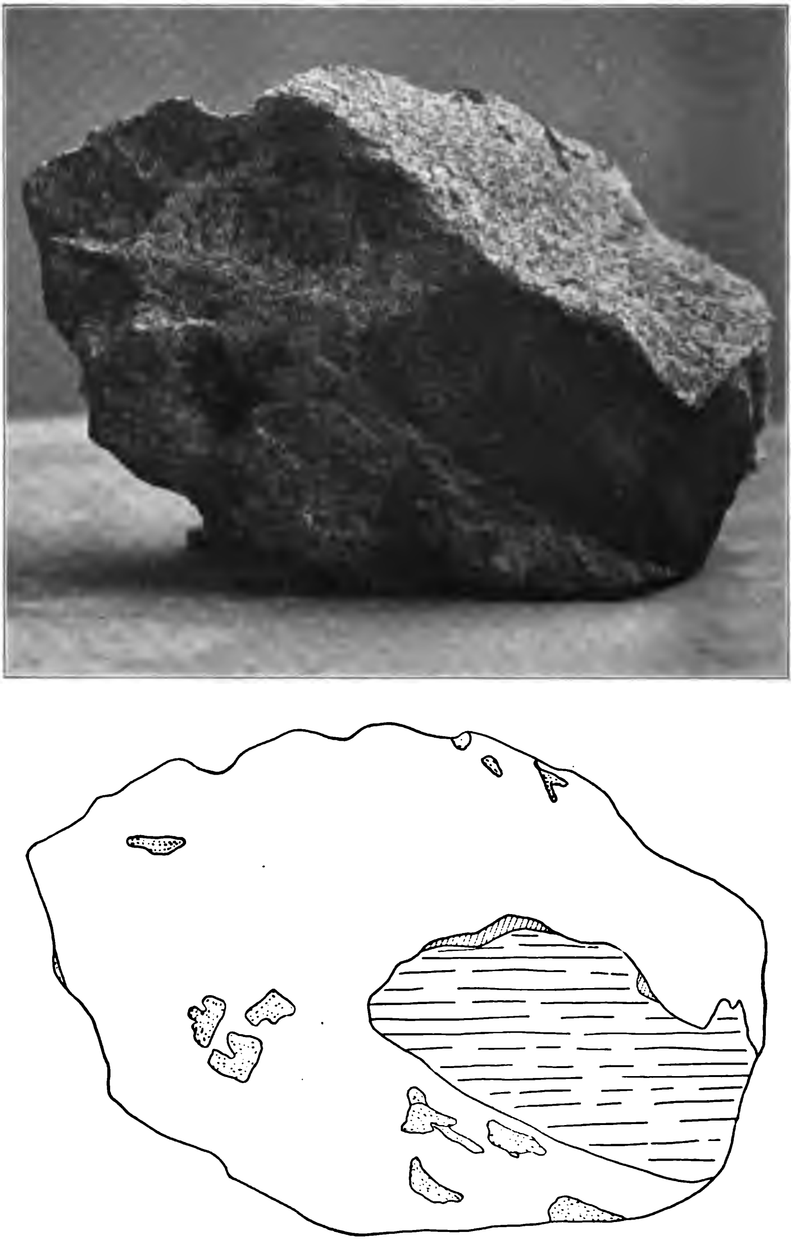
[1] *Trans.*, xxxi., 182 (1901).

[2] *Engineering and Mining Journal*, vol. lxxix., p. 125 (1905).

FIG. 1.—SHAFT-HOUSE OF THE EVERGREEN MINE. THE DIKE FORMS THE CREST OF THE RIDGE.



Spotted areas, Bornite. Obliquely shaded areas, Chalcopyrite.
Horizontally shaded areas, Inclosed Fragments of Wall-Rock.
FIG. 2.—SPECIMEN OF EVERGREENITE, THE ERUPTIVE ROCK OF THE DIKE, CONTAINING ORE. (Two-thirds natural size.)

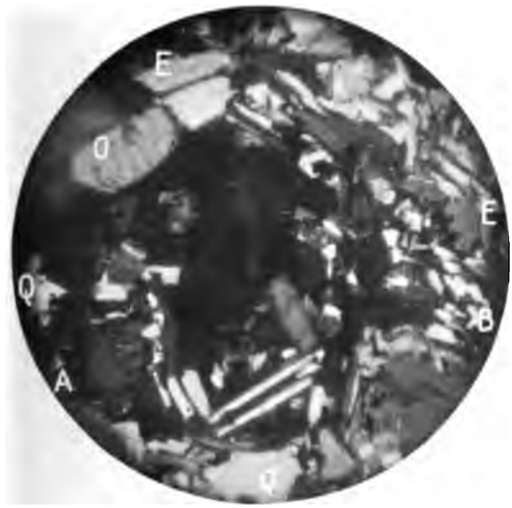


FIG. 3.—The opaque areas, B, bornite; dark-shaded areas, A, augite-ægirine; long white needles, E, enstatite or diallage, light areas with few cracks, O, an alkali feldspar, orthoclase, albite or microperthite; other light areas, Q, quartz. (Without analyzer. Magnified 71 diameters.)

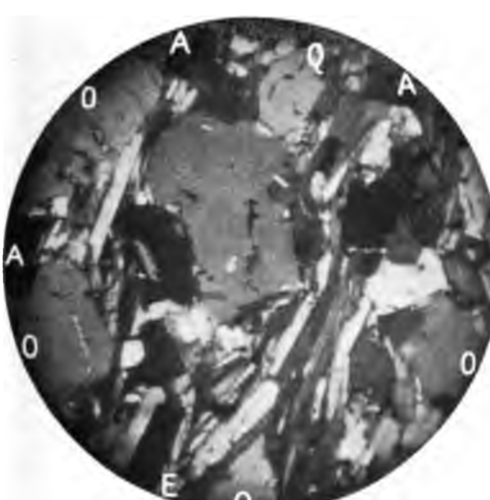


FIG. 4.—"Evergreenite" with porphyritic structure. The large crystal in the center is quartz, containing inclusions of bornite. (With analyzer. Magnified 71 diameters.)

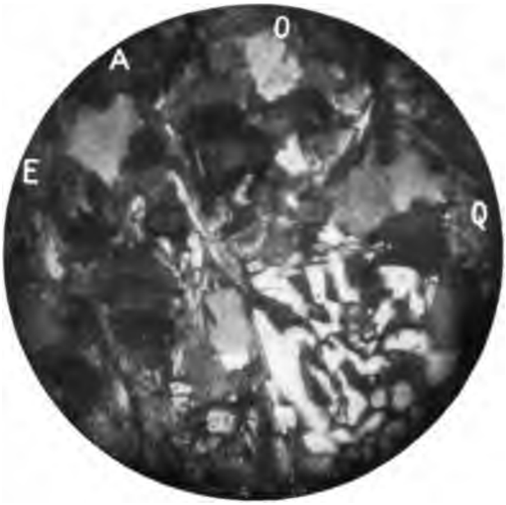


FIG. 5.—"Evergreenite," intermediate between microgranitic and porphyritic types, but without bornite. Note a patch of granophyre. (With analyzer. Magnified 71 diameters.)

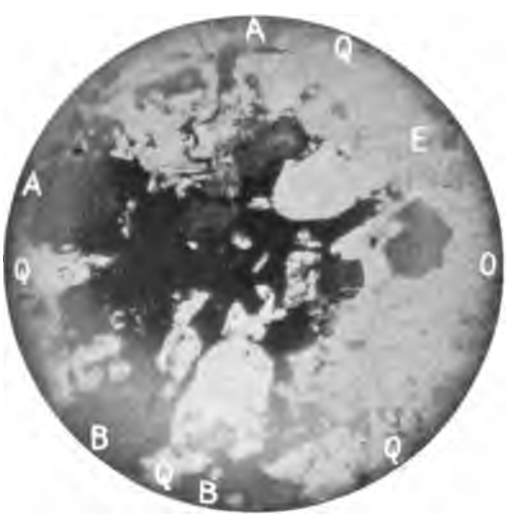


FIG. 6.—Bornite surrounding crystals of quartz, enstatite and augite-ægirine, and itself surrounded by the same minerals and orthoclase, with inclusions of bornite in the quartz and the augite. (Without analyzer. Magnified 71 diameters.)

and has had as advocates Fuchs and de Launay in France, J. H. L. Vogt in Norway, A. Schenk in Germany and B. Lotti in Italy.

Among the conspicuous examples of such deposits are the copper-deposits of the Banat on the boundary of Hungary and of Roumania; the celebrated ore-deposit of Monte Catini,[3] and others less important, found in Tuscany;[4] and the ore-deposits of Ookiep,[5] in the Kleinnamaland, in South Africa; also some deposits in Prince of Wales Island, Alaska,[6] and Shingle Springs, California.[7]

THE PETROLOGY OF THE ORE-DEPOSIT.

The Evergreen ore-deposit lies at an altitude of 10,200 ft., on the eastern slope of the Front Range. It crops out on a hill with a northerly exposure, where the snow remains on the ground for six or seven months every year, preventing the formation of an oxidized zone of any importance. The dike has taken its name from the Evergreen claim, which covers it for 1,500 ft. in length. It is opened at its lower end by a tunnel about 700 ft. long, and by a shaft with three levels, at 100, 150 and 200 ft. The dike strikes nearly N–S. and dips from 65° to 75° E. It is not followed continuously by any level, but it has been cut by the levels, and in several places followed for some distance.

In the dike, as exposed by the mine-workings, a fair amount of the original ore has been left unaltered by subsequent action. This is due to the tightness of the eruptive rock. The metamorphosed zones of the gneisses and altered crystalline schists, on both sides of the dike, have been much less impervious to the circulation of vadose waters; and a secondary enrichment can be observed in these zones.

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[3] Fuchs et de Launay, *Traité des gîtes minéraux et métallifères*, vol. i., p. 660, and vol. ii., p. 230 et suiv.; also L. de Launay, Contribution à l' Étude des Gîtes Métallifères, *Annales des Mines*, Ninth Series, vol. xii., pp. 119 to 228 (1897).

[4] B. Lotti, La miniera di Montecatini, *Bollettino del Reale Comitato Geologico d' Italia*, vol. xv. (1884).

[5] A. Schenck, *Zeitschrift der Deutschen Geologischen Gesellschaft*, vol. liii., p. 64 (Verhandlungen der Gesellschaft) (1901).

[6] W. W. Rush. A Curious Occurrence of Copper, *Mining and Scientific Press*, vol. xciii., p. 624 (1906).

[7] C. Y. Knight. A Curious Occurrence of Copper, *Mining and Scientific Press*, vol. xciv., p. 242 (1907).

The eruptive rock composing the dike is of a new type, as illustrated in Figs. 3 and 4. It shows a wide range in structure, varying from micrograpitic to porphyritic, with all the intermediate stages, as shown in Fig. 5.

The micrographitic part is more acid than the porphyritic; the crystalline schists of the metamorphosed zone have been transformed by an injection of the magma of the more acid type.

In the acid type, the phenocrysts are those of the alkali feldspars, mostly microperthite. They are very fresh, and contain some microscopic needles of enstatite and of diallage lined up in their cleavages. The crystals are seldom broken, and when that happens, the narrow cracks are filled by very small flakes of sericite.

The older quartz occurs in large and irregular grains, more broken than the feldspar crystals; the several grains forming a large patch do not die out simultaneously.

The few phenocrysts of ægirine show strong pleochroism. They are surrounded by belts of granulitic quartz, intergrown with numerous tabular crystals of ægirine, and needles of enstatite and of diallage showing all kinds of orientation. There are but few sections of the sphene, and fewer still of magnetite. A typical micropegmatitic intergrowth of quartz and feldspar occurs in small patches, giving arborescent figures in polarized light. The specimens of this class are richer in feldspar and poorer in pyroxene than those of porphyritic texture.

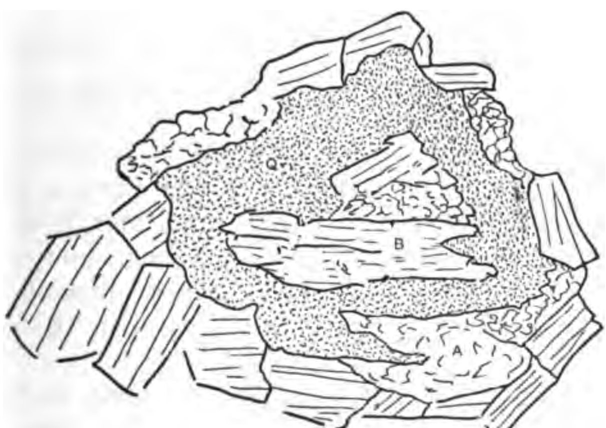
In the latter, it seems that the segregation of the magma is more advanced, and there is a consequent decrease in the amount of the feldspars. These specimens show a part (more acid) specially rich in quartz, and another part (more basic) characterized by the abundance of needles of enstatite and of diallage, with sharp crystalline forms, lined up almost well enough to indicate a direction of flowage. There are very few phenocrysts of intra-telluric formation surrounded by a groundmass of smaller ones. On the contrary, there seems to have been only one period of crystallization; and all the crystals are of about the same size.

The augite is in smaller amount, while the needles of enstatite and of diallage are more numerous than in the other micrographitic type. There is very little magnetite or sphene. The

rock is also very fresh in this type, and shows no decomposition-products.

This freshness of the rock is in striking contrast with the altered condition of the country-rock around it and is a strong argument in favor of a Tertiary age for the dike. While the time of its ascent can only be guessed at, we may not unreasonably associate it with that of so many Tertiary volcanic rocks, which form a long N–S. belt on the eastern slope of the Front Range.

The included fragments torn from the wall-rock are more numerous in the micrograntic than in the porphyritic part of the dike. They consist of crystalline schists, rich in biotite



A, Augite. B, Biotite. L, Leucoxene. Q, Quartz.

FIG. 7.—WALL-ROCK SURROUNDED BY AUGITE, IN A SLIDE OF ERUPTIVE ROCK. (Magnified 40 times.)

and in magnetite, with feldspars always thoroughly sericitized. The biotite is not altered. These inclusions are of all sizes, from that of a phenocryst, perhaps 0.02 in. in diameter, to several cubic feet. The smallest inclusions are often surrounded by a belt of small tabular crystals of augite (Fig. 7). Their line of contact with the eruptive rock is sharp. In the few cases where the included fragment of the wall-rock has been partly resorbed by the magma of the eruptive rock, it appears as a ground-mass of microgranitic quartz, sericite, magnetite, biotite and leucoxene, without any marked texture. Cubes of pyrite or of chalcopyrite are sometimes seen in these fragments.

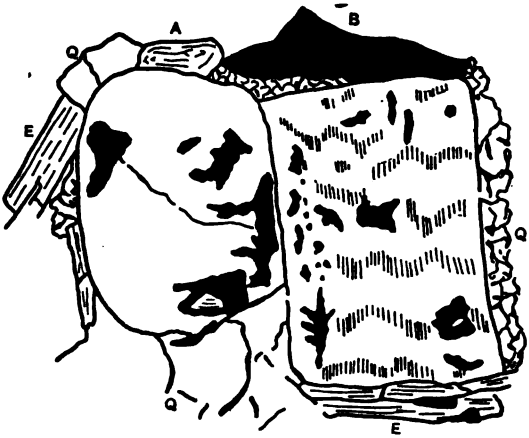
The crystalline schists cut and metamorphosed by the dike show two main types of rocks. They have been changed either into pseudo-gneisses or into pseudo-quartzites. In the first case, they are made mostly of alkali feldspars (orthoclase and albite, occurring often as microperthite). These have been largely changed into sericite; there are few crystals of oligoclase and some large and broken quartz-grains. The crystals of biotite are broken, but they are rather fresh. In places they have lost their pleochroism and their interference-colors; but they have not been changed into a new mineral. More than half of the rock is made of feldspars. The sections show also a few grains of magnetite and some larger grains of pyrite, of chalcopyrite and, more seldom, of bornite. The ægirine is more abundant and occurs in crystals without sharp outlines, green, but lacking in pleochroism. It is often partly changed into leucoxene.

The quartzose injection has changed the original crystalline schists into a ground-mass very rich in quartz. The biotite is in needles, smaller and more numerous than in the pseudo-gneisses; the magnetite is more abundant and the ægirine less so. The feldspars are mostly oligoclase; their crystals are smaller and less numerous than in the gneissic type.

The most instructive sections are those showing the relations between the copper-minerals and the eruptive rock. These sections may be divided into two groups—those which show bornite only as the copper-mineral, exhibiting also very plainly the relations of the bornite as a rock-forming mineral; and those which show not only bornite, but chalcopyrite and some covellite also. This latter group comprises also the sections in which the ore is at the contact of the inclosed fragments of wall-rock with the eruptive magma. The relations between the silicates of the eruptive magma and the copper sulphides are not so easily deciphered in them; and in places the action of secondary agencies can be plainly detected.

The slides of the first group show not only that the bornite is a rock-mineral, but also that it has not crystallized at a single time. Being a sulphide instead of a silicate, it has possessed special fluidity; and, as a result, it is found as inclusions in the quartz, the feldspars (Fig. 8), the ægirine and in

the clusters made by the needles of enstatite and of diallage, showing that it crystallized sometimes before any one of these



A, Augite. B, Bornite. E, Enstatite. Q, Quartz.
FIG. 8.—QUARTZ- AND ORTHOCLASE-CRYSTALS WITH INCLUSIONS OF BORNITE. (Magnified 40 times.)

minerals (Fig. 9). On the other hand, the patches of bornite, which contain as inclusions, at one spot or another, each one

A, Augite. B, Bornite. E, Enstatite.
FIG. 9.—AUGITE WITH INCLUSIONS OF BORNITE. (Magnified 40 times.)

of these various silicates, show that the bornite crystallized last of all (Fig. 10). A curious slide shows an intergrowth of

crystals of enstatite, diallage and bornite, with a texture similar to that of the quartz and feldspar in "graphic granite" (Fig. 11).

A, Augite. E, Enstatite. O, Orthoclase. Q, Quartz.

FIG. 10.—AUGITE, ENSTATITE, ORTHOCLASE AND QUARTZ SURROUNDED BY BORNITE. (Magnified 30 times.)

The accompanying sketches and microphotographs show these facts better than a long description (See Figs. 2 to 12).

Only small parts of the ore-deposit exhibit secondary en-

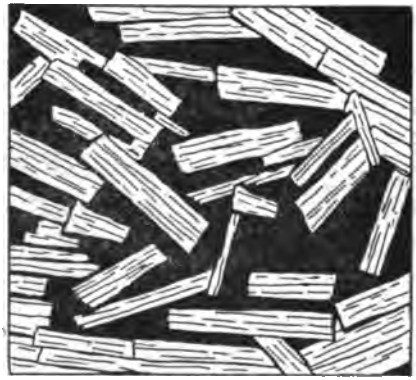


FIG. 11.—BORNITE AND NEEDLES OF ENSTATITE AND DIALLAGE INTERLOCKED, WITH THE TEXTURE OF A GRAPHIC GRANITE. (Magnified 50 times.)

richment; and these parts are always in the midst of the metamorphosed crystalline schists, at their contact with the eruptive rock of the dike.

In these crystalline schists, the exomorphic addition of magma consists chiefly of quartz and ægirine. There has been a partial resorption of the broken mass of the schists by the granophyric quartz; and the tabular crystals of augite are scattered through that ground-mass. There is every indication that the quartz of the ground-mass is primary and that it has not been deposited by the descending waters which have changed the bornite and the chalcopyrite into covellite. The freshness of the broken crystals of augite and of biotite, which have kept their pleochroism, as well as the texture of the ground-mass of quartz, are opposed to such a secondary deposition.

The metasomatism is localized and concentrated along the channels of water-circulation, and never extends beyond a narrow margin on each side of them. Even in the slides in which the bornite has been altered into covellite, it is easy to recognize the primary characteristics of the former as a rock-mineral. The metasomatic action has failed to change the outlines of the patches of bornite, or their relations with the neighboring crystals of the eruptive rock. The relations of the covellite with the bornite and with the chalcopyrite are plainly those of a secondary mineral. They show a striking contrast with the relations of the bornite and chalcopyrite towards one another.

These two minerals occur as primary materials of the rock. They are distributed in separated patches, sometimes wide apart, sometimes adjoining one another, or following each other, along the general trend of flowage marked by the parallelism of the microlites of enstatite and diallage. But neither of them ever forms a margin to the other, following its various embayments, and neither ever penetrates the other along a line of fracture, as is always the case with the covellite. I have never been able to observe a case in which the chalcopyrite has been enriched and changed into bornite, as is often the case in copper-deposits. The secondary enrichment of the chalcopyrite, like that of the bornite, always gives covellite and limonite. I have also failed to observe any such transformation, by leaching, of bornite into chalcopyrite as has been observed by Mr. Jules Catherinet in the primary bornite of the Similkameen deposits. The bornite and the chalcopy-

rite act towards each other like two minerals of slightly different chemical compositions which have crystallized at the same time, during the cooling of the eruptive magma, as did, for instance, the augite and the enstatite or the diallage in the "Evergreenite."

On the contrary, the secondary enrichment, transforming bornite and chalcopyrite into covellite, with formation of secondary limonite, is very plain (Fig. 12). The alteration has

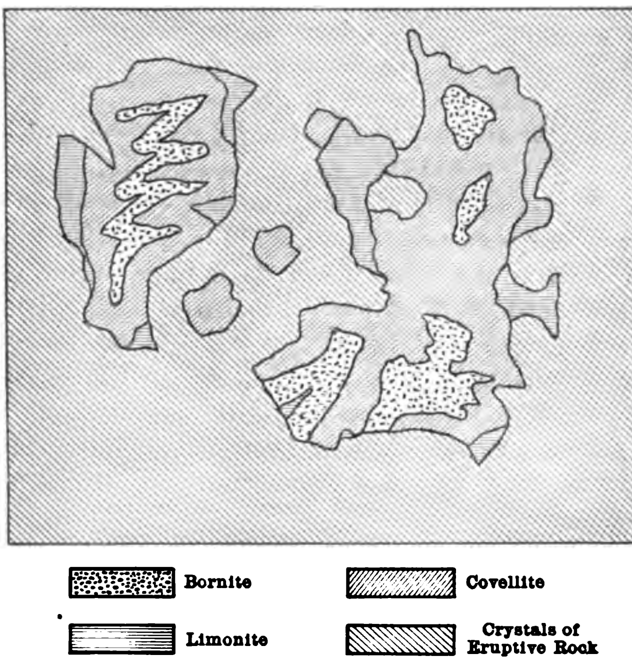


Fig. 12.—Sketch Showing the Alteration of Bornite into Limonite and Covellite.

begun along the margin of the patches of these minerals and has penetrated all the crevices towards the heart of their crystals. As the rock has been but slightly compressed, its crystals are seldom broken; and this has handicapped the work of the copper-bearing solutions. Only the smallest patches of bornite have been completely altered into covellite and limonite, without leaving any trace of the primary mineral. In almost every case the covellite forms only a margin surrounding more or less completely the patch of bornite or of chalco-

pyrite, allowing every step of the metasomatic process to be easily followed.

This secondary enrichment is the only alteration shown by the ore, and it is always accompanied by a strong alteration of the feldspars and of the neighboring augite. If the alteration of the eruptive rock near the covellite is very striking, it is also quite local and stops within a very short distance. The feldspars show little sericitization, but all their cleavages are lined with limonite. The same features can be observed as to the ægirine. That mineral has always lost its pleochroism and is often also altered more or less completely into leucoxene.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Pure Coal as a Basis for the Comparison of Bituminous Coals.

BY W. F. WHEELER,* URBANA, ILL.

(Toronto Meeting, July, 1907.)

In the study of the coals of Illinois now being carried on by the State Geological Survey, an attempt is being made to determine the most satisfactory basis of comparison between different coals. The following discussion is based upon work done for the survey in the laboratories of the State University and under the general direction of Prof. S. W. Parr.

"Pure coal" has been defined by Mr. A. Bement[1] as ash- and moisture-free coal, and the use of this "pure coal" as a basis for comparing different bituminous coals has lately been much discussed among engineers in the middle West. By some the B.t.u. of the pure coal is being used to check calorimetric results, and to calculate the calorific value of different coal-samples from the same seam, for which purposes it is necessary to assume—first, that the composition and calorific value of pure coal from different parts of the same coal-seam are uniform, and, second, that these values remain constant after the coal is mined, both of which assumptions there are reasons to believe are inconsistent with the facts. Certain variables are included in pure coal, as ordinarily defined, and disregard of them may lead to serious error. In any event, where delicate shades of difference are involved, no sure interpretation of results can be made, unless these variables be eliminated.

As a basis of comparison between coals, ash- and moisture-free coal is much to be preferred to "dry coal," and still more is it to be preferred to "moist coal," as ordinarily reported in analyses. There are, however, two constituents other than ash and moisture which are similar in effect to them, and which

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[1] *Journal of the American Chemical Society*, vol. xxviii., pp. 632 to 639 (1906); *State Geological Survey of Illinois, Bulletin* No. 3, pp. 23 to 25 (1906).

constitute, therefore, variables. The first of these constituents, sulphur, is low in heat-value and variable in quantity, and figures for pure coal including it are misleading. The second constituent is the water of composition of the ash. It, too, is a variable for different ashes, and cannot be disregarded where close comparisons are to be made. The exclusion of the two larger variables, moisture and ash, does not justify calling ash- and moisture-free coal "pure coal," when it contains a widely varying amount of sulphur that is no more a part of it than the ash and moisture. Just because the mineral matter of the ash has sulphur combined with it, does not justify the inclusion of the sulphur as a part of the pure coal. An ideal pure coal should include the carbon, hydrogen, oxygen and nitrogen, and also the part of the sulphur that is not combined with the ash, that part which is in the coal in organic compounds. Practically, however, it is impossible to divide the sulphur between the ash and the pure coal, owing to difficulties arising in the determination of the organic and inorganic sulphur. When we know only the total quantity of sulphur in the coal, it is desirable to consider it all to be combined with iron as pyrite, and to discard it entirely, along with the ash and moisture. In thus considering the sulphur to be combined as pyrite, we must, in correcting for it, first correct the ash for the oxygen which is added to the iron in it to replace the sulphur. $2FeS_2 + 11 O = Fe_2O_3 + 4SO_2$. Three parts by weight of oxygen replaces eight parts of sulphur. This ratio gives us the easiest way of correcting the ash. Three-eighths of the sulphur subtracted from the ash will reduce the iron in it to the condition in which it was weighed in the coal. However, as we wish to discard the ash, moisture and sulphur, it is found more convenient to take the uncorrected ash plus the moisture and five-eighths of the sulphur from 100 per cent. and call the remainder sulphur-free pure coal. It will be easily seen that the method just given for calculating the percentage of pure coal in the moist coal will give the same result as is obtained by taking the corrected ash (the ash minus three-eighths of the sulphur), plus the total moisture and sulphur, from 100 per cent. The heat due to the sulphur in pyrite should not be credited to the pure coal, and is, therefore, to be deducted from it. According to

calculation,[3] this amounts to 40.5 B.t.u. for each per cent. of sulphur. The organic sulphur in any coal-seam is probably a fairly uniform proportion of the pure coal, and any variation or error caused by the proposed consideration of it as pyrite will be small and constant in nature, and can, therefore, be neglected in so far as it affects the use of pure coal as a basis for comparing bituminous coals of ordinary sulphur-content. Variations of as much as 300 B.t.u. in the heating-value of the ash- and moisture-free coal can be traced directly to the variations in the sulphur-content.

Table I. shows, for six samples of Illinois and Indiana coal, calorific efficiency in B.t.u. of the "pure coal" corrected for sulphur, and also of the same coal as ordinarily considered (ash- and moisture-free). These were commercial samples, taken in the Chicago market by Mr. E. H. Taylor, of the Fuel Engineering Co. Part of each was floated in a zinc sulphate solution (sp. gr., 1.35), in order to remove a portion of the sulphur and ash, and thus get more nearly a pure coal to work with. The agreement between the two portions of the same sample (floated and original) is seen to be very much better where the sulphur is excluded. Ash- and sulphur-values are given in per cent. of dry coal.

The lack of agreement in some of the samples after correction for sulphur may be accounted for by the second variable (the water chemically combined with the ash). It will be noted that in only one out of the six pairs of samples is the B.t.u. of the pure coal higher for the sample with the high ash than for the one low in ash, and in that case the difference in ash is small. The suggested explanation is, that part, at least, of the ash is fire-clay, having chemically-combined water which is lost when the ash is ignited, but is not lost in drying. This variation is not due to the method of calculating the pure coal, but it is due to an analytical difficulty in determining the ash, and this difficulty is one that it is almost impossible to overcome. It affects the ultimate analysis, the water of the ash appearing there as oxygen and hydrogen; and in the proximate analysis it appears as volatile matter. For ordinary purposes it does not cause any discrepancies of importance. It is only so much more water in

[3] Report of the St. Louis Fuel-Testing Plant for 1904.

TABLE I.—*Variation in Calorific Efficiency of Pure Coal with Differences in Ash.*

Sample No.	Kind of Coal.	Sulphur.		Ash, Uncorrected for Pyrite.		Corrected Pure Coal, Ash, Water and Pyrite Free.		Pure Coal, Ash and Water Free.	
		Original Coal.	Floated Coal.	Original Coal.	Floated Coal.	Original Coal.	Floated Coal.	Original Coal.	Floated Coal.
		Per Ct.	Per Ct.	Per Ct.	Per Ct.	B.t.u.	B.t.u.	B.t.u.	B.t.u.
1	Sangamon Co., Ill., Pawnee lump.......	5.99	...	11.66	...	14,319	...	13,987	...
2	Same as No. 1, floated	...	3.20	...	6.12	...	14,335	...	14,164
3	Sangamon Co., Ill., Latham screenings	4.25	...	18.21	...	14,285	...	14,031	...
4	Same as No. 3, floated	...	2.95	...	8.13	...	14,356	...	14,192
5	Williamson Co., Ill., Marion No. 5, washed nut................	1.86	...	12.83	...	14,471	...	14,361	...
6	Same as No. 5, floated	...	1.39	...	4.01	...	14,585	...	14,509
7	La Salle Co., Ill., washed screenings	3.43	...	10.05	...	14,517	...	14,316	...
8	Same as No. 7, floated	...	2.33	...	3.94	...	14,619	...	14,487
9	Vigo Co., Ind., Miami nut..............	7.62	...	16.21	...	14,653	...	14,170	...
10	Same as No. 9, floated	...	3.08	...	4.27	...	14,653	...	14,478
11	Sullivan Co., Ind., Reliance lump......	3.37	...	6.11	...	14,738	...	14,451	...
12	Same as No. 11, floated	...	1.29	...	2.53	...	14,709	...	14,624

the fuel, and it makes little difference for practical purposes whether that water was originally combined with the ash or with the coal. In extreme cases it might make a difference of as much as 2 or 3 per cent. in the ash-factor, but that would be only in the case of a low-grade coal very high in ash. In a coal containing 10 per cent. of fire-clay, having 10 per cent. of combined water, the difference in the ash, if determined, would be 1 per cent., and its effect, when calculated to the pure coal, would be to reduce the B.t.u. on that basis by about 1.1 per cent. Ten per cent. is not an unusual amount of combined water for a fire-clay. Different clays contain chemically-combined water varying from 5 to 12 per cent., and the average for Illinois fire-clays is somewhere near 8 per cent.

In an effort to determine the effect of variable ash on the B.t.u. of pure coal, eight samples from different mines produc-

ing Illinois "No. 7" coal were each separated into two portions, one of which floated and the other sank in a zinc sulphate solution of a sp. gr. of 1.30. The great variation in ash thus secured in identically the same coal accentuated any variations that might in any way be due to the ash. In all of the eight samples, the B.t.u. of the coal which sank was found to be materially lower than that which floated. The close agreement between the difference in the B.t.u. of the sulphur free pure coal and the difference in ash in the dry coal is shown in Table II.

TABLE II.—*Combined Water in the Ash, Calculated from the Difference Between the Calorific Efficiency of the Sulphur-Free Pure Coal in the Float- and Sink-Coal.*

Survey No. of Sample.	Comparison of Light and Heavy Portions of Same Coal.				Difference between Float- and Sink-Coal.		Difference in Weight of Ash in Raw Coal and in Cinder, due to Water of Composition, Expressed in Percentage of Raw Coal.	Difference in Weight of Ash Expressed in Percentage of Cinder.	Water of Composition of Ash Expressed in Percentage of Hydrated Ash.
	Float-Coal.		Sink-Coal.						
	B.t.u.	Ash.	B.t.u.	Ash.	B.t.u.	Ash.			
		Per Ct.		Per Ct.		Per Ct.	Per Cent.	Per Ct.	Per Ct.
104	14,462	4.64	14,227	18.00	235	13.36	1.3	9.7	8.8
105	14,510	3.83	14,271	14.43	239	10.60	1.4	13.2	11.7
106	14,414	4.22	14,096	22.17	318	17.95	1.7	9.5	8.7
107	14,404	2.56	14,343	9.52	61	6.96	0.4	5.8	5.5
108	14,587	4.08	14,374	17.75	213	13.67	1.2	8.8	8.1
109	14,657	4.34	14,434	18.28	223	13.94	1.2	8.6	7.9
112	14,641	3.40	14,558	10.89	83	7.49	0.5	6.7	6.3
113	14,718	3.23	14,602	13.41	116	10.18	0.7	6.9	6.5

On the assumption that the difference in calorific value was due to water combined with the ash and not to any variation in the sulphur-free pure coal in the two portions of the sample, the amount of water was calculated which would have to be com-

bined with the ash to entirely account for the difference in the B.t.u. of the sulphur-free pure coal. The amount of water thus calculated and shown in Table II. agrees remarkably well with that ordinarily found in fire-clays and shales, when the possible variations due to experimental error are considered. In the mines from which the coals of Table II. were taken, the floor is a fire-clay and the roof is a shale very similar in appearance to the floor. There is always present, too, a "blue band" of shale from about 0.5 to 2 in. thick. On the supposition that the composition of the ash in the coal was similar to that of some of these materials, analyses were made of the material composing the floor and the roof, and also of the thin parting of shale in the mine supplying samples Nos. 108 and 109.

	Water of Composition. Per Cent.	Carbon. Per Cent.
Floor,	5.62	Not determined.
Roof,	4.20	Not determined.
Shale parting,	7.51	5.74
Calculated for ash in No. 108,	8.1	
Calculated for ash in No. 109,	7.9	

The water of composition was determined by igniting strongly on the blast lamp after drying for 1.5 hours at 105° C. to remove all moisture.

The agreement between the water of composition of the floor and "blue band" and that calculated for samples Nos. 108 and 109 is so close that it seems that we would be almost justified in using results obtained directly on such material as being representative of the ash in the coal. From the limited data at hand the indications are that the clay and shale under the coal and in partings distributed through it are very similar to the ash in the coal. The average water of composition calculated for the ash in samples Nos. 108 and 109 is 8 per cent., for the floor it is 5.6 per cent., and for the "blue band" 7.5 per cent. If there were a difference of 150 B.t.u. of the pure coal due to the 8 per cent. of water of composition, we would have reduced the difference to 45 B.t.u. by using 5.6 per cent. in correcting for it. If we had used 7.5 per cent. instead of 5.6 per cent. we would have reduced the discrepancy to 9.4 B.t.u. In none but extreme cases would such a discrepancy reach 150 B.t.u., and then it would be reduced to an amount that would

not be very troublesome, by using the water of composition of the floor in correcting for it. It is doubtful if the water of composition of the ash, calculated from the analyses of "floated" and "sunk" samples, would be much, if any, more accurate than if it were obtained directly on the underlying material. The ash corrected by either of these methods would be represented in very nearly the condition in which it occurred in the coal.

In considering the possibility of using a constant B.t.u. for the sulphur-free pure coal from a given coal-seam for purposes of calculation and as a check on the calorimeter, we must take into account two other variables that have been overlooked heretofore, or have been thought to be of but minor importance. The first variable is the composition of the pure coal itself, which varies from top to bottom in the same bed, and is uniform for the whole bed only over limited areas. The second variable is due to the deterioration of the samples.

When the whole seam or corresponding sections of the seam are taken, the composition appears to be uniform for one mine, or for mines a mile or two apart, as in the case of samples Nos. 108 and 109, taken from the two mines of the Big Muddy Coal & Iron Co., east and west of Herrin respectively. The variation in composition of the different parts of the seam is so great as to make the coal indistinguishable from that of a number of other seams. The coal at the top of a seam is not the same as that at the bottom, and therefore samples from the same mine cannot be compared unless they represent the same portion of the coal-seam. The bottom coal in the Majestic mine, sample No. 106, has a calorific value of 14,338 B.t.u., while in the top coal, No. 109, it is 14,498, a difference of 160 B.t.u. for the two portions of the seam.

That there is an important variation in composition from point to point geographically is shown by the fact that eight samples of Illinois "No. 7" coal taken in Williamson and Franklin counties, Ill., show almost uniform decrease in the B.t.u. of the pure coal, going NW. from Marion. This difference (nearly 400 B.t.u.) must be considered.

Table III. shows the sulphur, ash and B.t.u. of the eight samples and Table IV. the falling off in their calorific value with increase in distance from Marion. Even though the de-

crease shown is not very uniform, it is marked enough to afford positive proof that the composition of the pure coal varies gradually from place to place. We have no explanation to offer for this variation unless it is due to difference in the thickness and porosity of the material overlying the coal, or to the difference in the vegetation from which the coal was formed.

TABLE III.—*Analyses of Samples of Illinois "No. 7" Coal.*

S. G. S. No.	Lab. No.	Sulphur in Dry Coal.	Ash in Dry Coal.	Pure Coal Free from Ash, Moisture and Sulphur.
		Per Cent.	Per Cent.	B.t.u.
104	419	0.60	10.11	14,480
105	420	0.91	7.53	14,445
106	421	0.98	14.71	14,338
107	422	0.76	6.13	14,498
108	459	1.02	8.48	14,615
109	460	1.12	10.13	14,615
112	461	1.19	8.08	14,644
113	462	1.89	7.67	14,781

TABLE IV.—*Decrease in Calorific Efficiency of Sulphur-Free Pure Coal with Increase in Distance from Marion.*

S. G. S. No.	Locality.	Distance and Direction from Marion.	Total Decrease.	Decrease Per Mile.
			B.t.u.	B.t.u.
108	Herrin	5 Miles NW.	166	33
109	Herrin	7 Miles NW.	166	24
104, 105	Ziegler	12 Miles NNW.	319	27
106, 107	Duquoin	19 Miles NW.	395	21
112	Sesser	23 Miles N.	137	6

In fact, the variation in pure coal noted in analyses of "No. 7" coal is almost as great as is shown in the analyses of the

different coal-seams of the State by the St. Louis fuel-testing plant of the United States Geological Survey.

Samples Nos. 104 and 105, taken from parts of the same mine a quarter of a mile apart, show practically the same B.t.u. for the sulphur-free pure coal. Samples No. 108 and 109, from mines two miles apart, show identically the same B.t.u., an exceptional agreement even for two analyses of the same sample. Unfortunately, no more analyses are at hand that have been made on fresh samples taken from the same coal-seam not more than two or three miles apart, except samples 106 and

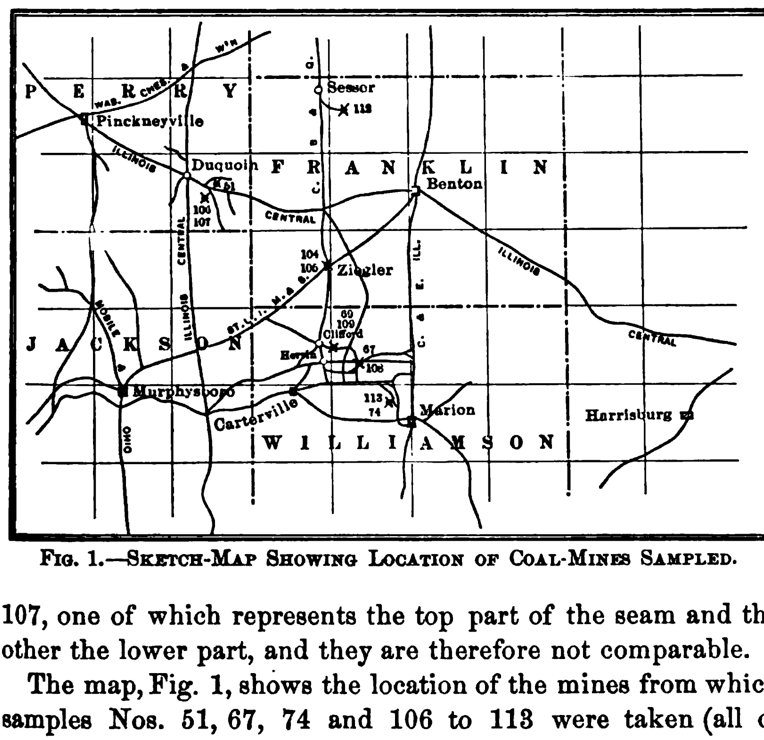

FIG. 1.—SKETCH-MAP SHOWING LOCATION OF COAL-MINES SAMPLED.

107, one of which represents the top part of the seam and the other the lower part, and they are therefore not comparable.

The map, Fig. 1, shows the location of the mines from which samples Nos. 51, 67, 74 and 106 to 113 were taken (all of Illinois "No. 7" coal). The location of the mines from which they were collected is marked on the map with an "X" and with the sample-number. All samples, except Nos. 106 and 107, represent complete sections of the working-face of the mine. No. 106 represents only the bottom coal, here 66 in. thick, while No. 107 represents the top coal, 30 in. thick, in an adjacent room. The complete list of samples discussed in this paper is given in Table V.

TABLE V.—*Description of Coal Samples.*

Sample No.	Name of Mine.	Location.	Date.	Collector.
			1906	
8	Sagamon Mine.	Springfield, Ill.	May 1	F. F. Grout.
9	Sangamon Mine.	Springfield, Ill.	May 5	L. J. Rutledge and H. F. Bain.
51	Paradise Coal & Coke Co.	Duquoin, Ill.	May 21	F. F. Grout.
67	Chicago & Carterville Coal Co.	Herrin, Ill.	May 31	F. F. Grout.
69	B. Muddy Coal & Iron Co., No. 8.	3.5 miles N. of Clifford, Ill.	June 1	F. F. Grout.
74	Peabody Coal Co., No. 8.	3 miles NW. of Marion, Ill.	June 26	F. F. Grout.
76	Kelly Coal Co., No. 4.	Westville, Ill.	May 6	Tom Moses.
77	Kelly Coal Co., Himrod Mine.	Himrod, Ill.	May 17	Tom Moses.
			1907	
104	Ziegler Coal Co.	Ziegler, Ill.	April 16	H. F. Bain.
105	Ziegler Coal Co.	Ziegler, Ill.	April 16	H. F. Bain.
106	Majestic Mine.	3 miles south of Duquoin, Ill.	April 17	H. F. Bain.
107	Majestic Mine.	3 miles South of Duquoin, Ill.	April 17	H. F. Bain.
108	Big M. Coal & Iron Co., No. 7.	Herrin, Ill.	April 18	H. F. Bain.
109	Big M. Coal & Iron Co., No. 8.	Clifford, Ill.	April 18	H. F. Bain.
112	Kelly Coal Co.	Sesser, Ill.	April 18	H. F. Bain.
113	Peabody, No. 3.	3 miles NW. of Marion, Ill.	April 18	H. F. Bain.
115	Sangamon Mine.	Springfield, Ill.	May 7	H. F. Bain.
117	Kelly Coal Co., No. 4.	Westville, Ill.	May 15	Bain and Moses.
118	Kelly Coal Co., Himrod M.	Himrod, Ill.	May 17	Bain and Moses.

In these studies a second important variable in the determination of pure coal is introduced by the deterioration of samples. The only analyses made use of as being representative of the coal as mined were those which were made within ten days of the time the samples were taken from the mine. That analyses of old samples do not represent the coal as mined, is indicated by the following circumstances:

It is known that combustible gas is liberated from moist laboratory-samples of coal when tightly sealed in glass jars and kept in a room of ordinary temperature, out of the direct sunlight. Evidence of this was afforded by a series of samples from all parts of Illinois studied in the course of our investigations. These were mine-samples, representing in each case the whole thickness of the coal-seam as mined, sampled down to about 700 g. at the mine and then placed in galvanized-

iron cans having a screw top, and a piece of insulating-tape wound around the top to make it air-tight. When these samples were received at the laboratory they were immediately transferred to quart "Lightning" jars with the exception of the last 21, which were put into ordinary screw-top Mason jars. These samples stood for from six months to nearly a year, when they were opened to be air-dried and analyzed. A slight gas-pressure was noted in the first jar opened, and after that each one was tested with a lighted match; 21 out of 50 samples were in Mason jars and showed no pressure, and none of them contained gas enough to ignite. Of the 29 in "Lightning" jars, two had been opened previously and showed no gas. In one other, the gas was not inflammable, but was evidently carbon dioxide or nitrogen, as it put out the flame. The remaining 24 samples contained gas in varying amounts, each one igniting readily and burning with a blue flame from 0.5 to 6 in. in height. No analysis was made of the gas. The probable explanation of the fact that no gas was found in the Mason jars is that they were not gas-tight. A series of analyses of these old samples, compared with fresh ones from the same or adjacent mines, shows the extent of loss in the calorific value of the sulphur-free pure coal. Every case shows a considerable deterioration in the old samples.

The facts set forth in Table VI. show that analyses should always be made soon after taking the sample from the mine, and that even under the best of conditions (sealed in air-tight jars), coal of the type found in Illinois and Indiana will lose from 2 to 4 per cent. in heating-power in one year. How much it would lose if exposed to the weather and how rapidly such loss would take place is now being studied, but results are not yet available. Probably the loss would be greater for coal exposed to the air than for samples sealed in air-tight jars. That the deterioration was not due to the fine size of the sample is indicated by the fact that the loss was found to be practically the same for both portions of the same samples sealed, one ground to 100-mesh size, and the other to buckwheat size. The loss of volatile hydrocarbons will account for part, at least, of the loss in calorific value. Whether or not the gases given off are products resulting from the decomposition of the coal,

TABLE VI.—*Deterioration of Coal Samples.*

S. G. S. No.	Lab. No.	Pure Coal Free from Ash, Moisture and Sulphur.	Time Between Collection and Analysis.	Deterioration in Calorific Value.
		B.t.u.		Per Cent.
51	307	14,116	1 year.	1.9
106–7	421–2	14,386	10 days.	....
67	323	14,321	1 year.	2.0
108	459	14,615	10 days.	....
69	325	14,213	1 year.	2.7
109	460	14,615	10 days.	....
74	330	14,335	1 year.	2.6
113	462	14,781	10 days.	....
8	81	13,940	7 months.	4.3
9	82	14,100	7 months.	3.2
116	540	14,567	1 week.	....
76	332	14,054	1 year.	2.8
117	557	14,450	5 days.	....
77	333	14,087	1 year.	3.3
118	558	14,564	5 days.	....

or whether they were simply occluded gases, has so far not been determined.

From the foregoing it seems clear that when delicate distinctions are to be made pure coal will furnish a better basis for comparison than any basis now in use; provided, of course, that correction be made for the sulphur and chemically-combined water in the ash. When these two factors are disregarded, the variations caused by them will be of sufficient magnitude to materially lessen the value that might otherwise attach to the pure-coal idea. It must not be forgotten, too, that any comparisons upon the pure-coal basis must take into account the fact that pure coal from one part of a seam is not the same as pure coal from another part of the same seam, there being a considerable variation, both vertically and horizontally. Probably the use for which pure coal is best adapted is for determining the extent of alteration in specific lots of coal in storage, but it is not without value for some of the other purposes mentioned. The calorific value of the sulphur-free pure coal may prove to be one of the most useful factors in classifying coals.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Calculation of Mine-Values.

BY R. B. BRINSMADE, ST. LOUIS, MO.

(New York Meeting, April, 1907.)

THE following is an attempt to form a formula by which a mine can be quickly evaluated, after all pertinent physical data have been collected from observations on the ground by a competent mining engineer.

ASSUMPTIONS.

Let G = price to be paid for the mining property.
" M = cost of developing the mining property to yield y tons of ore daily.
" P = cost of suitable plant to treat y tons of ore daily.
" p = value of said plant when the mine has been exhausted.
" C = total fixed capital investment.
" W = working capital investment.
Then " $C + W$ = total capital investment.
" y = required yield of ore daily in tons.
" Y = yield of ore yearly in tons.
" d = number of producing days per year.
" u = average operating profit per ton of ore.
" R = rate of interest to be earned on total investment of $(C + W)$.
" r = rate of interest to be earned on sinking fund annuity.
" v = tons of positive ore available in mine.
" x = tons of probable ore available in mine.
" z = tons of possible ore available in mine.
" m = fractional factor to change probable to positive ore.
" n = fractional factor to change possible to positive ore.
" Q = tons of total ore available in mine.
" t = time in years to exhaust mine at rate Y.

Let b = time in years for mine to reach production of y tons.

" A = annuity to be paid to sinking fund to equal C at end of t years at r, compound interest.

" a = annuity to be paid to sinking fund to equal C at end of t years at r, simple interest.

DERIVATION OF FORMULÆ.

We have directly from the foregoing assumptions the following equations:[1]

$$C = G + M + P \qquad (1).$$
$$Y = d\,y \qquad (2).$$
$$Q = v + mx + nz \qquad (3).$$
$$Q = tY \qquad (4.)$$

[1] In a contribution to the *Engineering and Mining Journal*, of March 14, 1903 (vol. lxxv., p. 40J), Mr. G. E. Collins has given a method of measuring v, x and z, and of determining safe values for m and n.

In this article he presents, as a practical example, a longitudinal section (Fig. 1) of a fissure-vein, the ore-reserves of which he classifies as "positive" (proved on three sides), "probable" (proved on two sides), and "possible" (proved on one side). Upon the case thus supposed, he makes the following remarks, which I deem worthy of preservation as generally applicable and instructive:

"Most of us have known, many of us have experienced, cases where blocks of ore so exposed [even] on four sides have been found to enclose a large barren patch in the center. However rigid a rule we may adopt, we cannot arrive at certainty.

"The amount of weight to be attached to exposure on four sides, on three, on two, or on one only, varies with the conditions of each particular case. . . . Who, after examining the section [Fig. 1], and bearing in mind the phenomenal lateral extension of the ore-body shown, can doubt, that far more reliance can be placed on blocks marked in the section as "positive ore," even although some of them are exposed on three sides only, than on many blocks opened up on four sides in veins where the ore-bodies are of the bunchy and erratic type which we must recognize to be, after all, by far the most frequently encountered? Even the "possible ore" of Fig. 1—ground where the ore is proved to exist on one side only—can be depended on to a far greater extent than usual.

"My contention is that the amount of evidence to be required when making estimates of ore tonnage, and the number and nature of classes into which estimates should be divided, must depend on our general conclusions as to the nature and permanence of the ore-bodies in the mines under consideration, the distance between the workings, etc. I do not think that any rules can be made which will lessen the necessity for dependence on the examining engineer's individual judgment; and I distrust all cast-iron classifications, which do not allow for the infinite complexity of natural conditions. The only useful general rule is that no estimate of tonnage should be made unless accompanied by sketches indicating the basis on which it rests."

Then since we must balance the two debits, of the interest to be paid during (t + b) years and the sinking-fund annuity to be paid during t years, against the two credits, of the operating profit from the total available ore and the selling value of the abandoned plant, we have:

$$(t + b)(C + W) R + tA = tYu + p \qquad (5).$$

To determine A, we can substitute in that algebraic formula for the annuity which involves the rate of compound interest, the number of annuity payments and the capital to be refunded and get:

$$A = \frac{Cr}{(1 + r)^t - 1} \qquad (6).$$

Substituting in (5) this value of A, we have:

$$(t + b)(C + W) R + \frac{tCr}{(1 + r)^t - 1} = tYu + p \qquad (7).$$

With the observed data, and equations (1), (2), (3), and (7), we can proceed to evaluate the mine. Equation (7) includes nine factors, any one of which, except t, can be determined by solving a simple equation. When t is unknown (as is commonly the case), it is difficult to solve the equation by common algebraic methods. To obviate this difficulty, it may be assumed that simple, instead of compound, interest is to be earned on the sinking-fund annuity; and the resulting difference in the result will act as a safeguard on the side of the mine-buyer. Additional safeguards for the buyer will be the assumption, in equation (7), that the factors C and W are invested at once, whereas their expenditure usually occupies a considerable period.

With simple interest, the sinking-fund annuity (a) becomes the first term of an arithmetical progression, of which the common difference is the annual interest (ar) gained on the annuity, the sum is the capital (C) to be repaid, and the number of terms is (t) the period of years. Then, by substitution in that algebraic formula for the sum which involves the first term, the common difference and the number of terms, we have:

$$C = \frac{t}{2}\left(2a + (t-1)\,ar\right) \text{ or } a = \frac{2\,C}{t\left(2 + r\,(t-1)\right)} \qquad (8).$$

Substituting this value of a for A in (5), we have:

$$(t + b)\,(C + W)\,R + \frac{2\,C}{2 + r\,(t-1)} = tYu + p \qquad (9).$$

To determine from equation (9) the unknown factor t, will involve only the solution of a quadratic equation; and this is most conveniently performed after the substitution of the numerical values of the other factors; since the direct solution for t, of (9) as a literal equation, is very lengthy.

If no interest be earned on the annuity payments, the second term of equation (9) will become equal to C, and we shall have:

$$(t + b)\,(C + W)\,R + C = tYu + p \qquad (10).$$

Since equation (10) involves only first powers, it can be used as a quick check on the approximate accuracy of the solution of equation (9) for t.

Practical Examples.

I.

On a certain property in the Southwest, examined by the writer, it was required to find the minimum available ore that must be found by prospecting operations to warrant the capital expenditure required to inaugurate production on a given scale. The unknown factors were hence Q and t, and the known were estimated from the collected data to be:

G = \$40,000; M = \$56,000; P = \$39,000; p = \$10,000; W = \$15,000; y = 100 tons; d = 300 days; u = \$3; R = 0.15; r = 0.06; b = 2 years.

From equation (1), C = 40,000 + 56,000 + 39,000 = \$135,000.

" " (2), Y = 300 × 100 = 30,000 tons.

" " (9), $(t + 2)\,(135{,}000 + 15{,}000)\,0.15 + \frac{2 \times 135{,}000}{2 + 0.06\,(t-1)}$
$= t\,(30{,}000 \times 3) + 10{,}000$; or

$$27\,t - 14 - \frac{108}{1.94 + 0.06\,t} = 0; \text{ or}$$

$$27\,t\,(1.94 + 0.06\,t) - 14\,(1.94 + 0.06\,t) - 108 = 0, \text{ or}$$
$$0.81\,t^2 + 25.77\,t - 67.58 = 0; \text{ whence}$$
$$t = 2.42 \text{ or } -34.24.$$

It is evident that the positive value of 2.42 years is the one desired.

Substituting the values of t and Y in equation (4), we have:

$$Q = 2.42 \times 30{,}000 = 72{,}600,$$

the number of tons of available ore, that should be found by prospecting, to satisfy the conditions of the case.

II.

A consumer, using 5,000 tons of a certain metal yearly, wishes to acquire a mine which would furnish his whole supply. He has found a mine which, by the expenditure, besides the purchase-price, of \$200,000 for development and plant, and the provision of \$50,000 working capital, would enable him to obtain annually the required supply of metal from 60,000 tons of its ore, at an operating profit of \$4 per ton. A year will be required to develop and equip the property, and the available ore will last, at the required rate of production, for twenty years, at the end of which period the plant will be worthless. If interest on the total investment be reckoned at 6 per cent. and on the sinking-fund annuity at 5 per cent., and if, in addition, it is necessary, while working the mine, to make a net saving of 1 cent a pound on the whole metal supply of the consumer, what price could he afford to pay for the mine?

Here C and G are the unknown factors, and we have:

$M + P = \$200{,}000$; $W = \$50{,}000$; $u = \$4$; $p = 0$; annual saving on metal, \$100,000; $Y = 60{,}000$ tons; $R = 0.06$; $r = 0.05$; $t = 20$ years; and $b = 1$ year.

From equation (1), $C = G + 200{,}000$.

Substituting this value in equation (7), and remembering that the sinking-fund annuity is to be increased by the \$100,000 of annual saving on metal supply, we have:

$$(20+1)(G + 200{,}000 + 50{,}000)\,0.06 + \frac{20\,(G + 200{,}000)\;0.05}{(1+0.05)^{20} - 1}$$
$$+ (20 \times 100{,}000) = (20 \times 60{,}000 \times 4) + 0; \text{ or}$$

$$1.26\,(G + 250{,}000) + \frac{G + 200{,}000}{2.654 - 1} + 2{,}000{,}000 = 4{,}800{,}000; \text{ or}$$

$$2.084\,(G + 250{,}000) + G + 200{,}000 + 1.654\,(2{,}000{,}000)$$
$$= 1.654\,(4{,}800{,}000); \text{ or}$$
$$G = \$1{,}264{,}500,$$

the maximum allowable price for the mine.

CONCLUSIONS.

The practical value of such calculations as the foregoing may be plausibly questioned, at least as regards all mines other than collieries, for which the quantity of available reserves can be estimated with a degree of confidence and precision not usually attainable in mines of the metallic ores. In reply to this probable criticism, I beg to offer the following observations:

1. There are, in fact, besides collieries, more mines than we commonly realize, the actual reserves of which can be measured, and the probable or potential reserves estimated. Among such I might instance many quarries, massive ore-bodies already explored by boring, etc. To all such cases, mathematical formulas of valuation are directly applicable.

2. With regard to the very large number of metal-mines, in which v, the certain ore-reserve, is relatively small, while x, the probable, and z, the possible reserve, are so uncertain as to make the determination of m and n, as the moduli representing reasonable expectation, merely a function of the temperament of the observer, I beg to say that, even in such cases, the observer himself may, very likely, be steadied in his judgment, and aided to form prudent conclusions, by such calculations as will clearly show him to what extent his hopes, fears and guesses enter into his opinions. It may seem absurd to employ mathematical methods in the discussion of data so largely indefinite; but the quantitative determination, even of our ignorance, is a recognized application of mathematics; and "the probable error" has a value of its own, not less real, though it be less authoritative, than the rigorously demonstrated certainty. In other words, I venture to believe that the discussion, by exact methods, even of more or less uncertain data, is a valuable check upon the hasty sentimental or temperamental general impressions which often claim the authority of conclu-

sions. Such a check is the more important, because many mining investors are tempted to overlook the essential proposition that a mine is "a candle, burning at both ends;" that its value is constantly diminished by its product; and that its annual profits must cover, not only a satisfactory income from the investment which has been made in it, but also the progressive repayment of the investment itself. All this sounds very elementary; yet it is too often overlooked in the enthusiasm of speculation. Each investor, if he thinks of it at all, dismisses it from his mind with the reflection that he will have abundant opportunity to "unload" during the period of dazzling prosperity which he foresees for the mine. This is the chief reason why mining has not yet become universally a regular business. That desirable result will be greatly promoted when investors purchase a mine, either with the positive intention, not of selling it out, but of working it out, or else, at a price based upon the hypothesis of such an intention. Consequently, the more this consideration is emphasized by theoretical calculations of value like the preceding, the better.

3. I should add my recognition of the elaborate paper of the late H. D. Hoskold,[2] Inspector General of Mines of the Argentine Republic, read before the Institute in October, 1902, which, by its more thorough mathematical treatment of this subject, might be held to supersede the present paper, but for two circumstances—namely, it seems to be mainly applicable to the valuation of collieries; and, by its retention of the formulas of compound interest for the calculation of sinking-funds and their corresponding annuities, renders the required calculations more complex and difficult than, in cases of less definite data, I think they really need to be. In the present paper, by abandoning the hypothesis of compound interest, I have reached a formula, precise enough for the nature of the data, and, because easier to apply, more likely in practice to be applied, than the more accurate one presented by this distinguished authority. As to the cardinal importance of a provision for the amortization of the invested capital, Mr. Hoskold sounds no uncertain note; and I may well be content to echo him.

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[2] The Valuation of Mines of Definite Average Income, *Trans.*, xxxiii., 777 to 789 (1903).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Biographical Notice of Thomas Septimus Austin.

BY ARTHUR S. DWIGHT, NEW YORK, N. Y.

(New York Meeting, February, 1908.)

The professional career of Thomas Septimus Austin, who died at El Paso, Tex., August 23, 1906, was contemporaneous with the growth of the silver-lead smelting-industry of the Far West, to which his talents and zeal contributed in no small degree.

Born at Stratford, Conn., December 7, 1853, he was the seventh son in a family of thirteen. His parents were well-to-do; and he received a thorough preliminary training at the Hopkins Grammar School, New Haven, Conn., passing thence to the Columbia School of Mines, in New York, where he was graduated in 1876.

His first professional work was that of analytical chemist with a Cuban sugar company. In this position he spent a year, and, whatever else of benefit he may have acquired during that year in Cuba, he gained a facility of speech in the Spanish language which was of inestimable value in his subsequent work in Mexico and the southwestern United States.

In 1877, he went to the Rocky Mountains, and, under the firm name of Murphy & Austin, opened an assay-office in Leadville, Colo., which was just then coming into public notice as a rich silver-lead camp. The next year, however, he entered the service of the Germania Smelting & Refining Co. at Salt Lake City, Utah, where he remained until 1882, first as assayer and chemist, and later as Assistant Superintendent. The Germania bears the honorable distinction of being one of the first of the large "custom" lead-smelters erected in the West. Its founders may be called the pioneers of the modern lead-smelting practice, and the Germania served, to a large extent, as a model for the many plants that sprang into existence during the next few years in Utah, southern Idaho, Colorado and other lead-producing districts. The formulation, for the first

time, of a logical and practically satisfactory working-theory of slags for the lead blast-furnace was a distinct advance, and constituted the keynote of this successful practice. In fact, the consistent pursuit of this practice became the distinguishing mark of that school of metallurgists, headed by Anton Eilers, August Raht and O. H. Hahn, and including many younger engineers trained by them, which has kept its identity clearly defined through the succeeding thirty-odd years of expansion and industrial change. Under the influence of this group of distinguished metallurgists, Mr. Austin was trained; and much of his thorough grasp of detail, and the sound metallurgical judgment which he displayed in his later work, must be credited to the invaluable discipline, and the correct molding of his fundamental professional habits, which he gained in this period of his career.

In 1882 he took charge of a newly erected silver-lead smelting-works at Ketchum, in the Wood River district of Idaho; but after a year he was obliged to relinquish this post and return to Salt Lake city, by reason of illness from lead-poisoning, which he had there contracted. In 1883 he again became connected with the Germania smelter, this time as Superintendent, and remained there until 1887, when he accepted the position of Superintendent of the Rio Grande Smelting Works at Socorro, N. M., newly built by the late Gustav Billing, and became an important contributor to its success. This establishment, under the management of Albert F. Schneider, a classmate and, at the Germania, a technical associate of Mr. Austin, enjoyed an exceptionally favorable basis in its supply of lead-ores, at first from the famous Kelley mine, near Socorro, and later from the mines of old Mexico. But the U. S. Treasury ruling of 1890, practically prohibiting the importation of lead-ores from Mexico, crippled the operations of the Socorro plant, and robbed it of its strategic importance, so that in 1891 it was obliged to suspend operations entirely.

On leaving Socorro, Mr. Austin made an engagement with Messrs. M. Guggenheim's Sons, who were about to embark in the construction of a new smelting-plant at Monterey, Mexico. This undertaking was beset with many serious difficulties, such as might be expected in the inauguration of a large technical industry in a new country. With his usual devotion to his

work, Austin did not spare himself; and his constitution suffered severely, and perhaps permanently, from the physical strain and unsuitable conditions of living thus incurred.

The first furnace of this plant was started in January, 1892. By the end of March, 1892, he had five, and by March, 1893, ten, furnaces in operation; but in September of the latter year his contract expired, and he was glad to give up the work in order to take much-needed rest and recuperation. The following period of leisure he devoted with characteristic zeal to a course in experimental electricity at Columbia University, being greatly impressed with the value of such knowledge in its bearing on the future development of metallurgy.

Early in 1894 he returned to the West, and engaged in general mining work in New Mexico, and later undertook to rehabilitate at Chihuahua, Mexico, a mining- and smelting-plant, which he operated successfully for a time. This enterprise was suddenly terminated, about the end of 1895, by a serious caving-in of the mine upon which it depended.

In August, 1897, the superintendency of the El Paso Smelting Works at El Paso, Tex., then a branch of the Consolidated Kansas City Smelting & Refining Co., was offered him by the writer, who, as General Superintendent of the company, had been at work for several months on a serious problem of reorganization. This plant enjoyed an unusually good strategic position, with an assured supply of suitable ores from the company's own mines and ore-buying agencies in Mexico and the Southwest. It had, in fact, everything needed for a highly profitable business, except economical operation. Its difficulties in this respect were complicated and deep-seated, but had at last been correctly located, and a plan of readjustment had been inaugurated, which finally brought success. This scheme, besides calling for the solution of many perplexing technical problems, required the gradual remodeling of the plant, and the building up, by patient and intelligent discipline, of a reliable force of trained Mexican furnace-men from the irresponsible class peculiar to the border country. It was the very task for which Austin was fitted by temperament and training; and the company was fortunate indeed in securing his services. For the next nine years, constituting the remainder of his busy life, he was engaged in the continuous

prosecution of this work, with a signal success which brought ever-broadening usefulness and responsibility. To his metallurgical skill, he added that wonderful constructive patience which is content to weave, thread by thread, the fabric of success. Such a combination is unconquerable.

His men caught his spirit and transmuted it into results. The El Paso plant soon came to be noted for the excellence of its metallurgical practice and the efficiency of its organization, while the earnings showed corresponding improvement, so that the works took rank among the most profitable in the country.

By the great merger of smelting interests accomplished in 1899, the El Paso plant passed under the ownership of the American Smelting & Refining Co., but without disturbing Austin's work. In July, 1901, during his temporary absence from El Paso, the blast-furnace department of his plant was completely destroyed by fire. This disaster was a blessing in disguise, since it enabled him to put into practice some of his well-digested theories regarding furnace-construction and the handling of materials. The system of mechanical charging of the blast-furnaces which he then inaugurated and perfected has proved highly successful in practice. The new power-plant of modern design greatly cheapened the cost of motive-power, and rendered possible many economies throughout the works. By December, 1902, the furnaces were again in operation; and the El Paso plant stands to-day as one of the most economical and thoroughly satisfactory lead-smelting establishments on this continent. In its recognized excellence of design and detail, its efficient technical organization and its well-balanced practice, it presents an honorable and indelible record of Austin's professional skill and unwearied industry.

It was natural that such ripe experience and judgment as his should be called into consultation when technical difficulties arose at other plants of the American Smelting & Refining Co.; and thus the scope of his duties was gradually enlarged until, in 1903, he was appointed General Superintendent of the Southern Department of that company, including, through the recent acquisition of the Guggenheim interests, sundry silver-lead plants in Mexico, as well as that of El Paso. Besides his purely technical work in this capacity, he had a voice in the

settlement of commercial questions, concerning which his judgment was always helpful in council.

In the summer of 1906, his health, undermined by his unremitting work, suddenly failed. Accepting too late this warning, he was, in August, just starting on a fishing-trip for rest and relaxation, when he was stricken with diabetes, and died after an acute illness of but two days.

His death was not only a great loss to his profession, but also a sorrow and shock to a large circle of professional friends and business associates, who had long esteemed him as a man of rare character and abilities. Most of all was he mourned by the many young engineers whom he had trained in his art, and whose affection he had won by personal kindness and painstaking interest, while his knowledge and skill had commanded their respect. His workmen also honored and loved him; for all of them, from the American foreman to the humblest Mexican laborer, had always found him a sympathetic listener and a just arbitrator of any real grievance. Behind his quiet, unobtrusive manner there was a great reserve force which all instinctively recognized, and to which all responded with their best service. And thus he was more than an ordinary "good judge of men," since he saw in them not only what they actually were, but also what they had the capacity to become, under the stimulus and guidance which he could supply. This is a higher and rarer gift than the mere mechanical judgment, however keen and accurate, which weighs a man just as he is, without discerning or inquiring whether he can grow. And this higher gift not only serves immediate business interests: it wins the love and loyalty of men—which is, in fact, a business asset of no small value.

Mr. Austin's engrossing duties as an executive or adviser doubtless prevented him, as so many other brilliant men have been prevented in similar circumstances, from systematic study in his own specialties, and from making such a record of his observations as might hand down to his successors the knowledge he had gained. He remained to the end a diligent student, and, moreover, he was able to state his views and conclusions with clearness and force. It is a great pity that he never found time to do this, in logical and comprehensive form, through contributions to current technical literature.

Fortunately, he committed to writing, in the form of private letters, many of his technical results and opinions; and some of these have been edited and published, since his death, in the *Mining and Scientific Press* of San Francisco, by his brother, Prof. L. S. Austin, of the Michigan College of Mines. Although these articles lack the consecutive, logical and comprehensive character which they would have possessed if originally prepared for publication by T. S. Austin himself, they contain many valuable facts and suggestions concerning the art of lead-smelting.

Mr. Austin married in June, 1890, Miss Dorothy Lockhart of Albuquerque, N. M., who, with one daughter, survives him. His domestic life was happy, and afforded him great solace and stimulus.

He became a member of the Institute in 1883.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Production of Converter-Matte from Copper-Concentrates by Pot-Roasting and Smelting.

BY GEORGE A. PACKARD, BOSTON, MASS.

(Toronto Meeting, July, 1907.)

THE experiments here described were made under my supervision while temporarily acting as head of the Department of Metallurgy at the Missouri School of Mines, at Rolla. The work was done by Messrs. W. E. Brown, W. C. Richards, and F. L. L. Wilson, and the description of the results forms a portion of a thesis presented for the degree of Bachelor of Science. These results are submitted because I have seen no description of the application of pot-roasting to the treatment of a copper-concentrate.

This work followed that already described in the discussion of the "Lime-Roasting of a Galena-Concentrate,"[1] and was similarly occasioned by the lack of a furnace of the reverberatory type in which the copper-concentrates could be smelted. The material for the tests was a mixture of three lots available. The first consisted of 8-mm. jig-concentrates and the second of 0.5-mm. table-concentrates, from the San Juan district, Colo. Both contained pyrite, chalcopyrite and galena. The third was a lot of copper-ore, found in the laboratory, which had been crushed through 8-mm. screen, and had at some previous time, before the laboratory roasting-furnace was torn down, received a partial roasting. The analyses of these ores are given in Table I.

In order to determine the applicability of pot-roasting as to each lot of ore, and the effect of varying proportions of lime, six preliminary tests were made in a "size N" Battersea crucible, 9 in. high by 6 in. in diameter at top, with a ⅜-in. hole bored through the bottom. The crucible was set in the upturned elbow of a 2-in. pipe, the joint being luted with clay; and air was obtained from a receiver supplied by a compressor. The

[1] Discussion of paper of H. O. Hofman and others, *Bi-Monthly Bulletin*, No. 16, July, 1907, p. 603.

TABLE I.—*Analyses of Materials Treated.*

	Jig-Concentrates. Per Cent.	Table-Concentrates. Per Cent.	Partly Roasted Ore. Per Cent.
Fe,	31.97	36.60	27.20
Cu,	6.32	4.65	8.34
S,	38.85	44.10	6.48
Pb,	1.25	1.04	......
CaO,	0.73	0.63	3.91
SiO_2,	17.42	10.32	12.48
Al_2O_3,	4.93	3.72	15.05
Au—oz. per ton,	0.03	0.16	trace
Ag—oz. per ton,	7.47	6.25	1.0

limestone, crushed through 8 mm., was mixed with the ore, and the mixture was well moistened before charging. No effort was made in these experiments to obtain a mixture corresponding to any definite slag-formula. The results obtained are given in Table II.

TABLE II.—*Crucible Experiments.*

Experiment No.	1.	2.	3.	4.	5.	6.
Weight, table-concentrates,	....	1,000 g.	500 g.	300 g.	300 g.	300 g.
Weight, jig-concentrates,	1,000 g.	....	500 g.	300 g.	300 g.	300 g.
Weight, roasted ore,	....	....	......	400 g.	400 g.	400 g.
Weight, limestone,	200 g.	200 g.	200 g.	100 g.	200 g.	300 g.
Total weight after roast,	838 g.	....	898 g.	847 g.	968 g.	1,024 g.
Sulphur—						
Before, per cent.,	32.37	....	34.56	24.98	22.89	21.14
After, per cent.,	5.16	....	15.09	10.78	10.67	7.55
Eliminated, per cent.,	88.89	....	67.32	66.77	62.41	71.86
Blast, in inches of water,	3 to 4	....	2 to 4	2 to 4	4	4
Time, in minutes,	69	....	40	35	34	34

Experiment No. 1, in which jig-concentrates only, mixed with 20 per cent. of limestone, were roasted, gave the best results, both in sulphur eliminated and in condition of product, which was quite solidly sintered, with but little loose, poorly roasted ore on top. The table-concentrates treated alone in No. 2 sintered very little; and it was evident that the method would not be applicable to such fine material unless it were mixed with coarser concentrates. Even then its presence in

large proportions was detrimental, as shown by the high percentage of sulphur in the sintered product after roasting in experiment No. 3.

In Nos. 4, 5 and 6, a mixture of the ores in about the proportion available was used, and the lime was varied from 10 to 20 and 30 per cent. While No. 6, containing 30 per cent. of limestone, shows the smallest amount of sulphur after roasting, No. 4 seemed to be a little more completely sintered; and, since less lime was necessary, the proportions of No. 4 were used for roasting in the large pot.

This pot was of $\frac{1}{16}$-in. iron, 25 in. in diameter at top, 15 in. at bottom, and 23 in. high, with a circular $\frac{1}{8}$-in. sheet-iron grate, 17 in. in diameter, 5.5 in. above the bottom. This grate had $\frac{3}{8}$-in. holes at 1.25-in. centers. The pot was set on a brick foundation having an opening in the center 9.5 in. square, into which air was delivered by the pipe from the receiver, the pressure being indicated by a water-gauge and regulated by a valve in the pipe.

The remainder of the ore, consisting of 253.5 lb. of partly roasted ore, 174.5 lb. of table-concentrates, and 158.5 lb. of jig-concentrates, was then mixed together, and 63 lb. of limestone was added. The mass, thoroughly moistened, was charged into the pot on top of a small amount of glowing charcoal, which rested on a quantity of coarse limestone sufficient to prevent the fines from falling through the holes in the grate. It was treated in three charges: the unsintered fines from the first two, plus the fines formed in crushing these, being added to the third. The weights, air-pressure, etc., are shown in Table III.

TABLE III.—*Results of Pot-Roasting.*

	Weight of Mixture. Lb.	Time. Hr.	Pressure in Inches of Water.
Charge No. 1,	200	5.75	10 to 14
Charge No. 2,	280	7	8 to 14
Charge No. 3,	308	8.25	8 to 14

Total weight of ore and limestone,	649.5 lb.
Total weight of product,	534.5 lb.

This shows a total loss in weight of 115 lb., including sulphur, carbon dioxide, and fines blown out by the blast, the latter being very small in amount. The product was well sintered,

practically constituting, in fact, a single lump, aside from about an inch of partly roasted material on top. The sintered portion was somewhat porous, though in places there were fused sulphides, resembling the heap-matte obtained in the heap-roasting of lump copper-ore when too strong a draft of air is admitted.

The entire product, including the fines from the last charge, was sampled down and analyzed, showing 16.17 per cent. of SiO_2, and 30.30 of Fe, 7.59 of Cu, 13.16 of Al_2O_3, 9.04 of CaO and 9.14 of S. This shows the elimination of 69 per cent. of the sulphur present. The gold, silver and lead were not determined.

This product, mixed with 13 per cent. of its weight of sandstone (nearly pure silica), and a small amount of old slag, and smelted in a small blast-furnace having a diameter of 26 in. at the tuyeres, yielded a matte carrying 32.11 per cent. of Cu, and 19.24 oz. of Ag and 0.12 oz. Au per ton.

This matte is low in copper for immediate converting, but the concentrates were probably somewhat lower in copper than would ordinarily be the case. The grade of the matte would probably also be increased in ordinary practice by the effect of the greater height of the furnace and the greater volume and pressure of blast, under which conditions more sulphur would be burned off. In our smelting of this small amount of ore the top of the ore-column was never more than 3 ft. above the tuyeres, and the blast-pressure never exceeded 5 in. of water. It also seems probable that the amount of sulphur in the sintered product might be decreased by the regulation of the blast so as to prevent the formation of the heap-matte in the pot. Another factor which here increased the sulphur going to the blast-furnace, and which would be eliminated in practice, was the inclusion of the partly roasted fines from the last pot-roast in the blast-furnace charge. These would ordinarily go to the next pot-charge. It seems possible to reduce the amount of these by careful attention, and by pressing them down with a heavy rabble when the charge is becoming red on top.

The preliminary experiments indicate another important factor in the amount of sulphur eliminated—namely, the coarseness of the material. Thus, the 0.5-mm. concentrates, treated alone, sintered but little; and the students did not consider the prod-

not worth working with. When mixed with an equal quantity of 8-mm. concentrates, the sulphur elimination was 67 per cent.; while the coarse concentrates, treated alone, gave up 88 per cent. of their sulphur, and sintered best of all.

The product obtained is, after crushing, in excellent condition for treatment in the blast-furnace; and, while it would doubtless not be economical to bring the sulphur down to a point representing a high-grade copper-matte, the production of a satisfactory matte for converting appears to be practicable. Where fuel is expensive, this method would apparently be cheaper than roasting and smelting the concentrates in a reverberatory, prior to converting.

The term "pot-roasting" has been preferred to "lime-roasting," because it has been shown with matte-roasting, in the West, that the presence of lime is not, though a certain amount of silica apparently is, necessary to the formation of a sintered product. (I question if the same may not be true in the roasting of galena.)

In the case of these concentrates, the operation seemed to present conditions analogous to those existing at the top of a furnace in which pyritic smelting is done. At first, dense yellow sulphur-fumes were evolved; and the sublimed sulphur collected on the cold objects in the vicinity. After a short time, the white sulphur dioxide fumes became more prominent, and continued until the end of the roast.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Destruction of the Salt-Works in the Colorado Desert by the Salton Sea.

BY WM. P. BLAKE, TUCSON, ARIZ.

(Toronto Meeting, July, 1907.)

THE salt-beds at Salton, on the line of the Southern Pacific railway, in San Diego county, California, have been successfully worked for many years by the corporation known as the East Liverpool Salt Co., and the salt has been largely used upon the Pacific coast generally and in the interior. But the industry has lately been destroyed by the overflow from the Colorado river. The salt is dissolved, and the waves of the Salton sea now roll 50 ft. above the site of this once thriving and growing business.

The salt-bed was evidently the residual accumulation from the waters of an ancient lake, which I have named Cahuilla, from the name by which a large part of the valley—the home of the Cahuilla tribe of Indians—is known. The deposit covered a comparatively small area in the lowest part of the valley, 280 ft. or more below the sea-level. This depressed area is now generally known as the Colorado desert, but has a soil of wonderful fertility wherever water can be had on its surface.

The deserted beaches, and the water-lines, only a few feet above tide-level, upon the rocks of the bordering mountains, as well as a great abundance of shells in the soil, all bear decisive testimony to the former occupation of the valley by water.

The depression is topographically the northern end of the Gulf of California, from which it is now separated by the delta of the Colorado river, extending practically from the mouth of the Gila river across the valley to the coast mountains on the west side. We may conclude that the imprisoned salt water was gradually displaced and freshened by the inflow and outflow of the river, so that the lake was changed to fresh or brackish water, with enough salt in it to give a bed at the bottom upon

the final evaporation of the lake-water after the Colorado had shut itself off.

It is also possible that the salt-bed owed its origin to springs of salt water, which are known to exist, and are by some supposed to indicate a connection with the water of the Gulf.

A deep valley lying west of the Cocopah mountains is occupied by a lake of salt water, known as Laguna Salada. It appears to receive occasionally accessions of sea-water and also of fresh water, by the way of Hardy's branch of the Colorado delta.

It is estimated by Mr. Arthur P. Davis, Assistant Chief Engineer of the U. S. Reclamation Service, that, if the inflow of the Colorado to the Salton is prevented, the sea will dry up by evaporation in about 10 or 12 years. Under such conditions we may expect the restoration of the salt-bed and a possible renewal of the industry.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Promontorio Silver-Mine, Durango, Mexico.

BY FRANCIS CHURCH LINCOLN,* NEW YORK, N. Y.

(Toronto Meeting, July, 1907.)

I. Situation and Surroundings.

The Promontorio mine is situated at the northern end of the Sierra San Francisco de Coneto, in the town of Promontorio, Partido of El Oro, State of Durango, Mexico. As shown in the sketch-map, Fig. 1, the nearest railroad station is Chinacates on the Mexican International Railroad, 82 miles north of the city of Durango. The mine is 16 miles north of the station by air-line. It is reached by means of a good wagon-road which first crosses the Guatimapé Plain, passing the ranches of San Antonio and San Julian, to Estacion—a distance of about 15.5 miles—and then entering the mountains crosses the Sierra to Promontorio—a further distance of 11.5 miles—making in all a distance of 27 miles by road from railroad to mine.

Promontorio is just beyond the summit of the range, at an elevation of about 8,000 ft. above sea-level, or 1,350 ft. above the Chinacates station. The Castillo de San Francisco, the highest peak in the Sierra, has an altitude of 10,000 ft., and the Promontorio road crosses the summit of the ridge at an elevation of 9,000 ft. by a pass just below this peak known as the Puerto del Almagre. The Promontorio mill is situated at Santa Inés, 2 miles by tram or 3 miles by wagon-road to the north of Promontorio and about 600 ft. lower.

The Sierra San Francisco de Coneto decreases in height towards the north and west till it comes to an end at the Melchor Arroyo on the ranches of Melchor and Ramos. Beyond this *arroyo* another range, the Sierra de la Candela, begins. In the vicinity of the Promontorio mine the hills are very rugged and the surface is furrowed by ravines which contain running streams during the rainy season—July, August and

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September—but are dry throughout the rest of the year. Fig. 2 is a view of the Promontorio mine, looking east, showing the

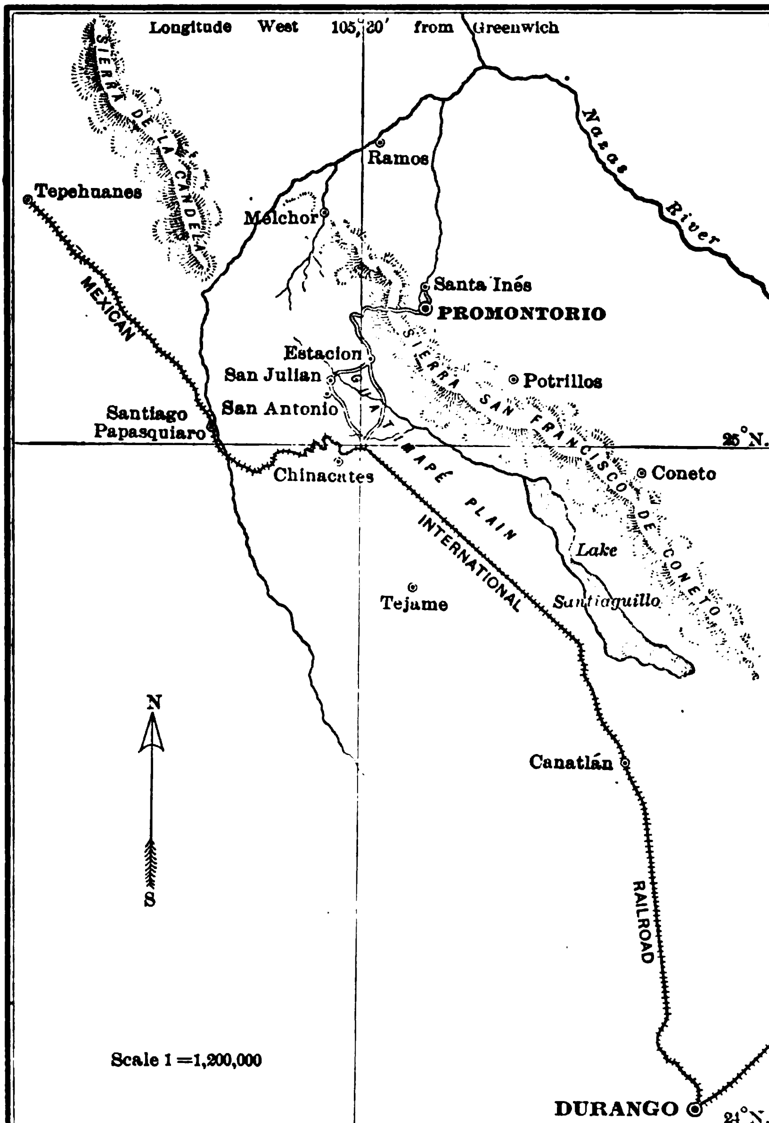

Fig. 1.—Map of Part of Durango, Mexico.

Refugio shaft-house in the ravine, the San Joaquin dump on the hill, the administration buildings on the left, and the power-

house on the right. Fig. 3 is another view, looking northward. The nearest permanent flowing water is the Melchor Arroya, a

FIG. 2.—THE PROMONTORIO MINE, LOOKING EAST.

good-sized stream which might be utilized for power. A considerable number of large pine-trees are still standing on the slopes of the hills immediately adjacent to the mine, while a short distance away, oaks and other small trees are fairly

abundant as well, promising a readily available supply of mine-timbers and fire-wood for a long time to come.

FIG. 3.– THE PROMONTORIO MINE, LOOKING NORTH.

II. THE COUNTRY-ROCK.

The country-rock of Promontorio is a rhyolite-porphyry. The ground-mass is glassy, showing flow-lines, and the pheno-crysts are large quartzes and orthoclases, together with

smaller and somewhat altered hornblendes. Small grains of magnetite are rather plentiful, and a much lesser number of little crystals of pyrite are to be seen. The rock is, therefore, a typical rhyolite-porphyry, and undoubtedly belongs to the Tertiary rhyolites so common throughout the Sierra Madre of Mexico.

Of special interest are the inclusions. The principal ones are small, dark, angular fragments, less than an inch in diameter, which are distributed rather plentifully in some parts of the porphyry. Microscopic examination shows these inclusions to be fragments of andesite and dacite, which were evidently broken from older rocks and brought up from a depth by the rhyolite-porphyry. Occasional rounded pieces of binary granite, from several inches to a foot in diameter, are also to be observed in the porphyry. These may have been broken off from underlying-rock like the andesite and dacite; or they may be simply segregations, since they are composed of quartz and orthoclase, the commonest phenocrysts of the porphyry. According to Ordoñez,[1] the succession of Tertiary eruptives in Mexico is similar in all districts, and may be summarized as follows:

Group No. 6, Basalts—Andesitic basalts.
Group No. 5, Dacites—Andesites.
Group No. 4, Rhyolites.
Group No. 3, Andesites—Dacites.
Group No. 2, Diorites—Diabases.
Group No. 1, Granites—Granulites.

If this order is correct, the Promontorio rhyolite-porphyry belongs to group No. 4. The dark inclusions in this porphyry show that group No. 3 is represented in depth by both andesite and dacite; the binary granite, if not a segregation, is representative of group No. 1; but inclusions indicating the existence of group No. 2 have not been discovered.

The Promontorio country-rock has a well-developed joint structure. It is split into sheets which range from less than an inch to more than a foot in thickness and are of considerable length and breadth. The strike of these sheets is

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[1] Las Rhyolitas de Mexico, *Boletín del Instituto Geológico de Mexico*, No. 14, p. 66 (1900).

about N. 20° W. (magnetic), and their dip nearly vertical but inclining slightly towards the northeast.

The only other rock in the vicinity of Promontorio is a rhyolite which caps the range. At Coneto, 28 miles SE., there is an outcrop of andesite of similar character to that of the inclusions in the porphyry.

III. The Vein.

The Promontorio vein strikes through the rhyolite-porphyry N. 55° W. (magnetic). Its dip is vertical at the surface, inclining towards the SW. in depth. Thus it cuts the joint-planes of the porphyry at an acute angle in both strike and dip. The Promontorio vein proper has been followed beneath ground for a horizontal distance of 2,660 ft., but it cannot be traced so far upon the surface because of the covering of soil. Below ground the vein still continues towards the SE., while to the NW. it forks, and the West vein, proceeding from the hanging-wall of the Promontorio vein proper, has been followed an additional distance of 968 ft. The West vein can be traced on the surface much farther, and is probably identical with the La Luz vein tunneled in a prospect far to the NW. of Promontorio. To the SE. no vein has been discovered which can be identified with the Promontorio vein. Either the vein has pinched out rapidly in that direction, or, as seems much more likely, the vein is older than the rhyolite which makes its appearance to the SE. and has been covered by it.

There are no parallel veins near the Promontorio, but there are numerous cross-courses, all of which fault the NW. part of the Promontorio vein toward the SW., the horizontal displacements varying from 1 to 13 ft. These cross-courses are in some instances simple faults, while in others they have become mineralized and constitute veins. The most noteworthy example is the Veta Dolores, which strikes N. 42° E. (magnetic) and can be traced as a well-defined quartz-vein all the way from Santa Inés to its junction with the Promontorio vein—2 miles—and for some distance beyond. Another important cross-course is known as the Veta Atravesada. It is much less marked than the Veta Dolores, strikes N. 28° E. (magnetic) and is possibly identical with the Los Naufragos vein which has been explored in a prospect to the SW. of Promontorio.

All the cross-courses dip steeply to the SE., which makes their junctions with the Promontorio vein pitch steeply in this direction also.

IV. The Ore.

The Promontorio vein is frequently divisible into three distinct parts: 1, a hanging-wall portion of vein-matter; 2, an intermediate portion of more or less altered country-rock, and 3, a foot-wall portion of vein-matter. The principal value of the ore is in silver, and sometimes one, sometimes another, portion of the vein is richest. In general, however, either the foot- or the hanging-wall portion contains the most silver, and the intermediate portion is most likely to be ore when both foot- and hanging-wall portions are rich.

Thus the Promontorio ore consists of vein-matter and mineralized country-rock. The characteristics of the fresh country-rock have already been described. It has been mineralized in two ways: 1, by silicification and impregnation with small scattered grains of the same sulphides as are found in the vein-matter; and 2, by the precipitation of secondary minerals in joint-cracks and decomposed spots.

The common primary vein-minerals are quartz, galena, and sphalerite, less pyrite, a very little chalcopyrite, and minute quantities of bornite, chalcocite, and covellite. The rare primary vein-minerals are tetrahedrite, chalcocite, argentite, and native gold. The oxidized vein-filling consists of quartz, kaolin, hematite, wad, and limonite, with occasional films of malachite and linarite and remains of the sulphides. The minerals which have contributed to the secondary enrichment are native silver, chalcocite, and a little chalcopyrite. The native silvèr does not contain even a trace of gold. Secondary enrichments occur both in oxidized portions of the vein and in the country-rock of the walls and horses.

Considering the frequency with which free silver is still encountered in the Promontorio mine, the rather even grade of the ore is somewhat surprising. In a systematic sampling of the mine, the highest result obtained was 263.6 oz. of silver per ton, and only 12 out of 1,059 assays exceeded 150 oz. per ton. The ratio by weight of gold to silver in the shipping-ore varies from 2:1,000 to 3:1,000 parts. The presence of small

amounts of copper-minerals always indicates a high silver-content, but in all cases where neither copper-minerals nor native silver can be identified in the vein-filling, assays are necessary to distinguish between ore and waste.

When the assays are plotted upon the mine-map, it is seen that the ore is arranged in shoots which, like the junctions between the Promontorio vein and cross-courses, all pitch steeply toward the SE. These shoots sometimes parallel the faults, while in other cases they are cut by the faults or occur in unfaulted parts of the vein. They are usually long and narrow, extending from 15 to 100 ft. along a level and cutting many levels on their pitch. After continuing downwards for a number of levels, shoots sometimes pinch out. New shoots may come in along the line of the old ones, or make their appearance in intermediate positions.

The shoots are either primary or secondary, both pitching in the same general direction. The primary shoots are distinguishable by their comparatively high content of sulphides, by their lack of secondary minerals, and by their habit of being cut off by faults unless occurring in unfaulted parts of the vein. On the other hand, the secondary shoots are recognizable by their low content of sulphides, by the presence in their richer portions of the secondary minerals, native silver, chalcocite, and chalcopyrite, and by their tendency to follow closely well-defined faults. The primary ore-shoots are dominant in the lower levels, the secondary in the upper. The secondary ore-shoots reach their maximum development in the neighborhood of the fourth level, where the Veta Dolores shoot extends horizontally for 460 ft. and the Veta Atravesada shoot for 456 ft.

None of the cross-veins have developed ore at a distance from the Promontorio vein, although small amounts of ore have been taken from some of them near their junctions with the Promontorio vein. Considerable prospecting has been carried on, but no other mine has been discovered in the district.

V. The Relations of the Primary Vein-Minerals.

Polished surfaces of the sulphide ore were prepared and examined microscopically under the direction and after the methods[2] of Dr. William Campbell, for whose assistance I desire to express my thanks. The specimens consisted, for the most part, of three minerals, galena, sphalerite, and quartz,

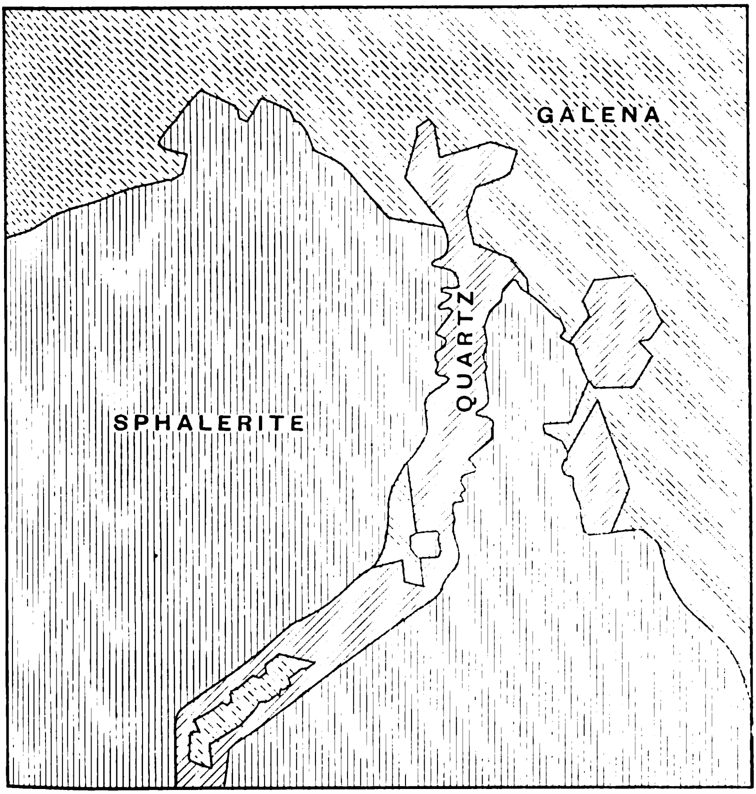

Fig. 4.—Low-Grade Sulphide Ore. (Magnified 80 times). Relations of Sphalerite, Quartz, and Galena.

whose relations are illustrated in Fig. 4. This shows that the sphalerite was formed first. It was fissured, and subsequently quartz was deposited in the fissures, and also in crystals on the exterior. Finally came galena, filling the vugs in the quartz-vein and molding itself about the previously deposited sphalerite and quartz.

[2] *Economic Geology*, vol. i., pp. 751 to 756 (1906).

Pyrite is an important component of the sulphide ore, though by no means so plentiful as sphalerite, galena, or quartz. The relation of pyrite to these minerals is clearly indicated in Fig. 5. Pyrite is there shown to be incrusted with sphalerite, which is, in turn, incrusted with quartz-crystals, while galena occupies all the remaining space, just as it does in Fig. 4. Pyrite, therefore, clearly antedates sphalerite, and was the first vein-minera to be formed.

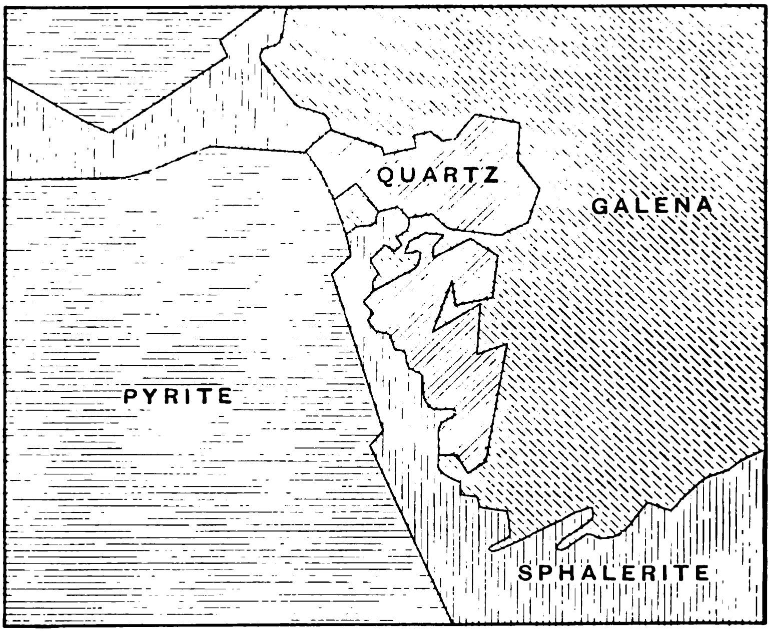

FIG. 5.—LOW-GRADE SULPHIDE ORE. (Magnified 80 times). RELATIONS OF PYRITE, SPHALERITE, QUARTZ, AND GALENA.

Chalcopyrite is a much rarer constituent of the primary ore. Its usual mode of occurrence, illustrated in Fig. 6, is in grains attached to the sphalerite and surrounded by galena. In this illustration one grain is shown surrounded by bornite and another is intimately associated with covellite. In other specimens chalcocite has been found in similar relations with chalcopyrite. These associations indicate that the minute amounts of bornite, chalcocite, and covellite found in the ore are probably secondary and derived from chalcopyrite. Chalcopyrite has not been found contiguous to quartz, but since it is entirely

absent from quartz-veins in sphalerite and present in galena-veins in this same mineral, it is reasonable to infer that it is

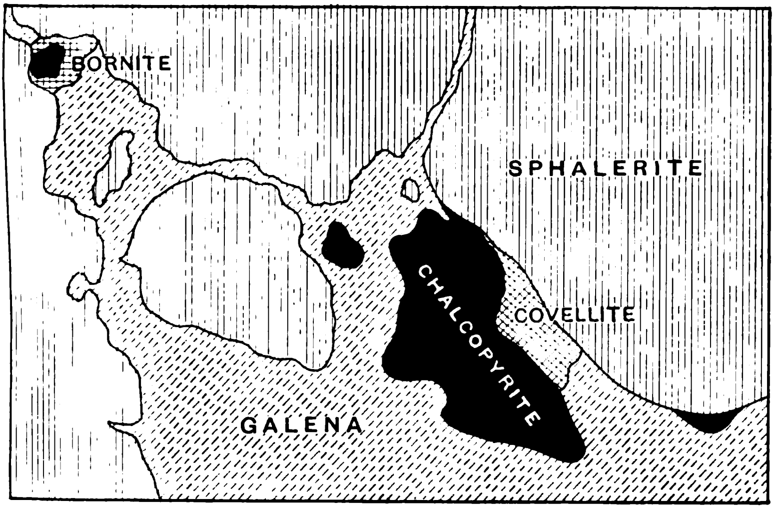

FIG. 6.—MEDIUM-GRADE SULPHIDE ORE. (Magnified 80 times). RELATIONS OF SPHALERITE, CHALCOPYRITE, COVELLITE, BORNITE, AND GALENA.

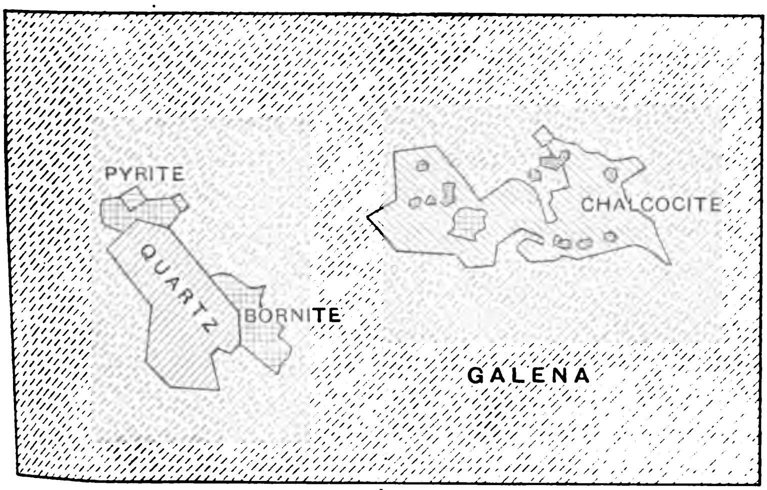

FIG. 7.—MEDIUM-GRADE SULPHIDE ORE. (Magnified 80 times). RELATIONS OF PYRITE, QUARTZ, BORNITE, CHALCOCITE, AND GALENA.

later than the quartz. The secondary copper-minerals associated with grains of pyrite are illustrated in Fig. 7, which

shows that the bornite is younger than the quartz and older than the chalcocite.

The order of succession of the minerals in the primary ore of Promontorio is therefore: 1, pyrite; 2, sphalerite; (period of crushing); 3, quartz; 4, chalcopyrite; 5, galena.

Rich primary minerals are exceedingly rare at the Promontorio mine. They play no recognized part in the mine's production, although they are probably present in minute amounts in the ordinary primary ore.

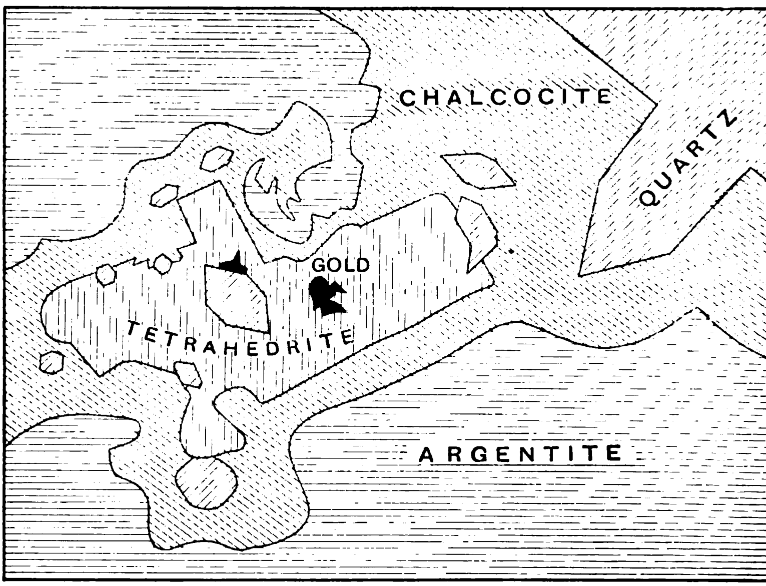

FIG. 8.—HIGH-GRADE SULPHIDE ORE. (Magnified 200 times). RELATIONS OF QUARTZ GOLD, TETRAHEDRITE, CHALCOCITE, AND ARGENTITE.

A specimen of rich ore obtained from the fourth level is apparently of primary origin. It consists of numerous metallic gray stringers and veinlets in milky white quartz. Polished surfaces, examined under the microscope, show the cavity-fillings to consist of tetrahedrite, chalcocite, argentite and native gold, arranged as illustrated by Figs. 8 and 9. (These minerals were identified by methods which I developed and shall soon publish.)

Quartz was deposited, then shattered, and native gold deposited upon it in small isolated crystals. Tetrahedrite came

next, forming detached crystals also, which occasionally surrounded gold. A crust of chalcocite then formed over all, and what gold had not already been involved in tetrahedrite became surrounded by chalcocite. This is indicated by Fig. 9. The section of veinlet there represented was completely filled with chalcocite, but in most instances the central parts of the crevices were left open and were filled later with argentite, as shown in Fig. 8.

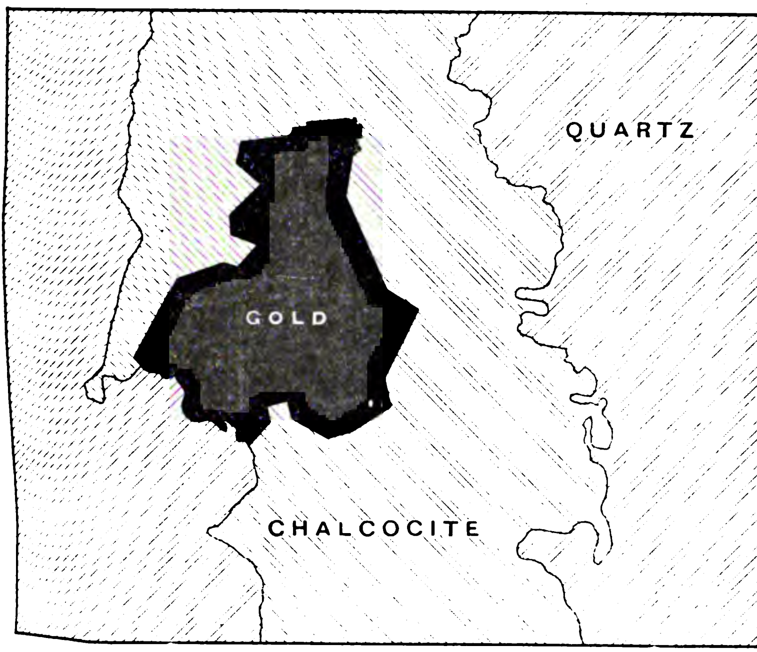

FIG. 9.—HIGH-GRADE SULPHIDE ORE. (Magnified 200 times). RELATIONS OF QUARTZ, GOLD, AND CHALCOCITE.

The order of succession in this rich piece of ore was therefore: 1, quartz; (period of crushing); 2, native gold; 3, tetrahedrite; 4, chalcocite; 5, argentite.

It will be noticed that the period of crushing came just after the deposition of quartz instead of just before, as in the ordinary primary ore. The difference in conditions thus clearly indicated probably caused the deposition of particularly rich ore at the point whence this specimen was taken.

VI. Geological History of the Promontorio District.

The Promontorio rhyolite-porphyry was extruded during Tertiary time through underlying andesite, dacite and, perhaps, binary granite. Pressure during cooling developed sheet-jointing.

After the consolidation of the porphyry a disturbance took place which resulted in the formation of an extensive NW.–SE. fault, through which heated ore-bearing solutions rose. This disturbance was probably caused by an intrusion of molten igneous rock that faulted the overlying layers and gave forth plutonic emanations, which, ascending through the fault, deposited the primary ore of the Promontorio vein.

The conditions were such that first pyrite, then sphalerite was deposited. A slight rearrangement along the fault led to the shattering of some of the pyrite and sphalerite, and at the same time brought about a change of conditions, so that quartz and, soon after, chalcopyrite were formed. Finally, galena was deposited in all remaining cavities, and the deposition of primary minerals came to an end.

After the mineralization of the Promontorio fault another upheaval took place, which was probably contemporaneous with the extrusion of the rhyolite that caps the Sierra San Francisco. This caused the formation of a series of NE.–SW. faults, several of which intersected the Promontorio vein. These faults were slightly mineralized, perhaps by lateral secretion from the porphyry, but certainly in a different manner from the Promontorio fault.

The district was covered by rhyolite for a while, but, when this was eroded, the only partly filled cross-faults formed convenient channels by which surface-waters were tapped off, and, entering the Promontorio vein in the neigborhood of these cross-faults, rearranged its contents. Rich deposits of secondary minerals were thus formed in the vicinity of the cross-courses.

VII. Mining.

The Promontorio mine was discovered by Joaquin Contreras in 1880, and purchased by its present owner, the Negociacion Minera de Promontorio, S. A., in 1887. It is at present the only real mine in the whole Sierra San Francisco de Coneto district. It should be noted, however, that the famous Po-

os tin-deposits are situated in these mountains, and that a em of silver-gold veins at Coneto has been worked interently for a long period of time.

Vhen mining began at Promontorio, it was necessary to ght the ore 260 miles to the railroad at Fresnillo. At that e, shipping-ore had to contain at least 240 oz. of silver per In 1892 the railroad reached the city of Durango, making ofitable to ship 90-oz. ore; and when, in 1900, the branch was opened to Chinacates, 60-oz. silver-ore could be ped at a profit.

he mine was first opened by the San Joaquin shaft, on a side (see Fig. 2), and later by the Cinco Señores workings, further up the hill. The present main working-shaft, the igio, is in the ravine beside the hill upon which the older ings are situated. The shaft-house is visible in Figs. 2 3.

his shaft has been sunk to a depth of 675 ft., of which the 280 ft. are in the vein, and 14 levels run from it. Levels 1 are 40 ft. apart; levels 9 to 14 are 71 ft. apart. Level 1 is nnel which starts at the mouth of the shaft and passes into hill to the SE. where it connects with the early workings tioned above. This level has the furthest extent towards SE. of any. The other levels are all drifts run in both diions on the vein for longer or shorter distances. Level 9 nds furthest towards the NW., passing the fork in the Protorio vein into the West vein and finally connecting with ther shaft, the Santa Maria, at a depth of 250 ft. From SE. face of the first level to the NW. face of the ninth l is a horizontal distance of 3,628 ft. A cross-cut from a t in the Santa Maria ravine a short distance below the ta Maria shaft intersects the fourth level and converts it a tunnel.

Vhen I visited the mine in the fall of 1906, the method of ation was as follows: All the material mined was trammed to a "*patio*" or sorting-yard by means of the cross-cut the fourth level. Rock mined above the fourth level dropped to it, and rock mined below was raised to it by hoist at the Refugio shaft. On the *patio* the produce he mine was sorted to "shipping" ore, running 60 oz. of er per ton, and better. The rejected material was thrown

on the milling-dump when it ran better than 20 oz., and on the waste-dump when worse. Since I left Promontorio, a mill has been started, and it is probable that ore of the grade formerly shipped is now being milled together with the lower-grade material.

The power-house, situated in a small *arroyo*, across from the main shaft (see Fig. 3), contains six tubular boilers, which burn wood and supply steam to the hoist and compressor, and to engines operating generators. The electricity generated supplies power at the *patio*, illuminates electric lamps, and operates the pumps. A 120-kw. alternating-current generator supplies the power to four 3-in. Worthington electric pumps. In the dry season the pumps are worked for 8-hr. a day, and raise about 96,000 gal. of water to the fourth level daily. Most of this water comes from the fourteenth level, a distance of 555 ft. In the rainy season, it is necessary to run the pumps 14-hr. a day, thus raising 168,000 gal. per day.

Fire-wood delivered at Promontorio costs $2.50 per cord and lumber $17.50 per 1,000 ft. The wages paid per day are:

Miners,	$0.75
Laborers,	0.375 to $0.75
Machine Drillers,	1.25
Shift Bosses,	1.00 to 1.25
Timbermen and Carpenters,	0.875
Blacksmiths,	1.25
Hoistmen,	1.25
Engineers,	1.00
Firemen,	0.625

Labor is, on the whole, plentiful. Some difficulty is experienced in keeping sufficient men at the mine during the periods of sowing and harvesting of crops, for the Durango laborer prefers farming to mining. Another peculiar condition has to be met in cold weather, when all hands want to work on night-shift because their cabins are too cold to sleep in at night, but are warmed to a more comfortable temperature by the sun during the day. With the exercise of a little tact there should be no difficulty in obtaining all the labor desired.

VIII. Milling.

illing operations did not prove a great success at Promon- in the early days of the mine. One brand-new mill, which never turned a wheel, was completely destroyed by the col- of a dam. Another mill was erected later, but failed to good extractions, as the tailings-dumps bear witness.

r. Gordon Wilson carried on a long series of milling-tests Promontorio ore, and came to the conclusion that the best ts could be obtained by concentration, followed by sliming cyanidation of the tails. His experiments indicated that er cent. of the values could be extracted by concentration) per cent. of the weight, and that, of the remaining 55 per , 89 per cent. of the silver, and practically all the gold, l be extracted by sliming and cyaniding for a period of 10 . This would mean a total extraction of 94 per cent. Mr. on, therefore, constructed a 50-metric-ton concentrating cyaniding mill at Santa Inés, which has now been in oper- for several months, and, I am informed, is performing .

e dam which supplies water for this mill is situated mid- between Promontorio and Santa Inés. It is 100 ft. high, was constructed at a cost of $50,000.

IX. Production.

e smelter-returns on shipments from Promontorio are re- ed to have been about $5,000,000. Unfortunately, no rec- of the quantities of gold and silver produced were kept ng the early bonanza days of the mine. From Dec. 5, 1896, ug. 18, 1906, there were produced and sold 5,689,618 oz. lver and 15,857.4 oz. of gold. During this period of re- ed production the Promontorio mine lost its position as of the largest producers of silver in Mexico,"[3] and became of the many minor producers. At present there is but little ping-ore in sight in the mine, but there are large reserves od milling-ore, and, with new and effective milling methods ll operation, we may soon expect to see the Promontorio make its way to the front once more.

[3] Ingalls, *Trans.*, xxv., 149 (1895).

RANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

ne Panoramic Camera Applied to Photo-Topographic Work.*

BY CHARLES WILL WRIGHT, WASHINGTON, D. C.

(Toronto Meeting, July, 1907.)

I. INTRODUCTION.

HE application of the camera as an adjunct to topographic ping began practically with its invention, and it has been em- ed with varying success since that time. With the excep- of the camera to be described, the plate-camera has been ersally used in this work, thus giving a projection of the photographed on a flat surface. From such projections or ographs, by the rules of geometry and of perspective, ts defining topographic features and seen from at least two era-stations may be projected upon a ground-plane—the [1]

1904 I employed the plate-camera for this purpose in ka, but found that the labor necessary to plot the maps, in a general way, was long and tedious. In 1905 a small man panoramic camera was fitted with spirit-levels, a sight- de and a transparent scale, introduced inside the camera egister the degree-points in the sky-line of the film-nega- also, arrows to indicate the horizon-line. This was, on whole, successful; but the details in the topography were brought out in the views with sufficient clearness, and the ographs were too small. These difficulties were overcome btaining a larger and more carefully constructed instru- t, which was satisfactorily employed in the field during the 1906.

panoramic view is made up of an integral number of per- tive views upon flat surfaces, and logically is the most ac-

* Published by permission of the Director of the U. S. Geological Survey.

1 anley, H. M. Photographic and Co-ordinate Surveying, *Trans.*, xx., 740 6 (1891). Also, Flemer, H. L. Photographic Methods and Instruments, t *U. S. Coast and Geodetic Survey*, pt. 2, app. 10, pp. 619 to 735 (1897).

curate and direct means to obtain an impression of a field of view for purposes of mapping. In the perspective view, only one line—the vertical center-line—records the direct azimuth or bearing of points within its perspective; and all other points must be determined by geometric projection, thus introducing an element of error. In the panoramic view, where the negative is everywhere equidistant from the camera lens and in its focal plane, the positions of all points are in direct horizontal angular relation to one another on the negative, as in nature; and by introducing a degree-scale which, at the time of exposure, is photographed in the sky-line of the negative, the bearing of any point relative to any other point within the view may be read from it directly.

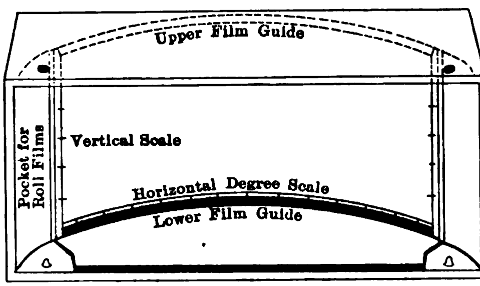

FIG. 1.—SKETCH OF PANORAMIC CAMERA WITH FRONT REMOVED, SHOWING POSITIONS OF HORIZONTAL AND VERTICAL SCALES.

The underlying principles of this method, therefore, do not differ essentially from those used in plane-table surveying. In all cases it is necessary either to have two points, within the area to be mapped, between which the horizontal distance has been determined; or, better, to have a preliminary triangulation of a number of the prominent points or peaks within the area which will form the base for the map, so that these determined triangulation-points may form tie-points for the camera-stations. It is then possible within certain areas to do the greater portion of the mapping with the aid of the camera alone. As in plane-table work, the traversing of trails and wagon-roads, and the determination of topographic stations, are more accurately made by an instrumental survey.

II. The Camera.

The camera best adapted for this purpose at present on the arket is the Al Vista camera, Model 5 B, which takes a 5-

Fig. 2.—The Panoramic Camera Fitted for Topographic Mapping.

y 12-in. view, including an angle of 140° (Fig. 2). It consists an oblong box, 6 in. by 6 in. by 11 in., fitted with a lens of d focus, which may be made to revolve at different speeds

FIG. 3.—RENDU GLACIER, GLACIER BAY, ALASKA.

Fig. 4.—Rendu Glacier, Glacier Bay, Alaska.

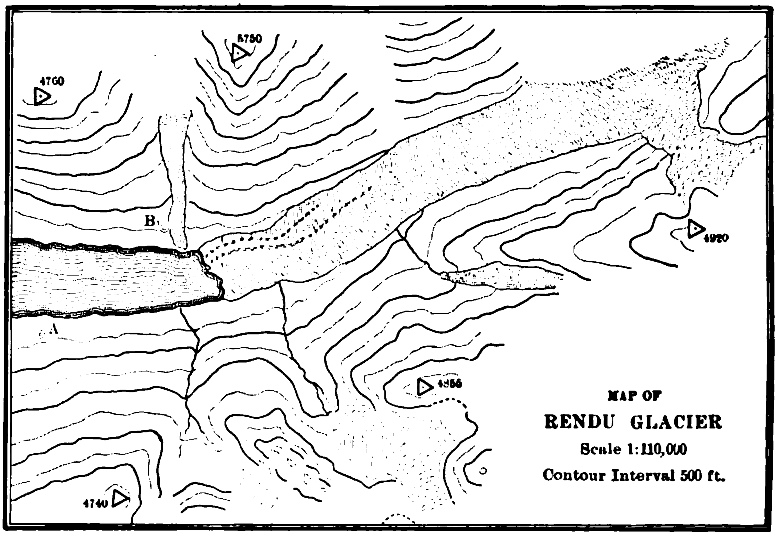

FIG. 5.—MAP OF RENDU GLACIER, GLACIER BAY, ALASKA. PLOTTED FROM FIGS. 3 AND 4.

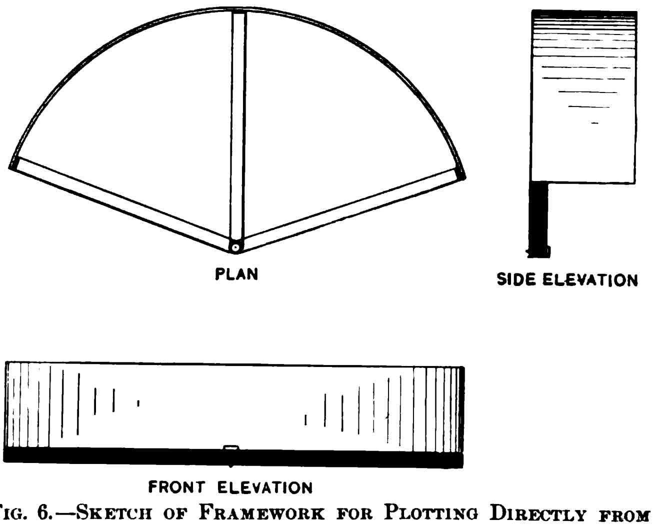

FIG. 6.—SKETCH OF FRAMEWORK FOR PLOTTING DIRECTLY FROM PHOTOGRAPH.

[6]

in a half-circle, and with the introduction of apertures of ous sizes allows the correct light-value for the exposure to btained. Retaining the film are two circular film-guides, laced, one at the top and one at the bottom of the camera- that the film, in passing outside of them, will be in the plane of the lens at all points. For more exact work, a era of this type should be constructed of metal, to elimi- the error which may be introduced by shrinkage of the den parts.

fit the camera for surveying, both a horizontal and a ver- scale should be so adjusted within the camera-box as to be ographed on the sensitized film at the time of exposure. To mplish this, a narrow strip of celluloid graduated into de- s ($1° = \frac{2 r \pi}{360}$ when r = focal length of lens) is glued to lower circular film-guide in such a way that the degree- ks project $\frac{1}{8}$ in. above the guide. The sensitized film passes ne outside of this, and when the exposure is made the de- s are photographed in the sky-line of the film. These de- -marks are nearly 0.1 in. apart on the negative; and on an rgement of two diameters, angular readings may easily be nated to an accuracy of 5 minutes.

n the sides of the upper and lower film-guides is attached in metal strip, 0.25 in. wide, in which wedge-shaped hes are made, the divisions (= $\frac{1}{20}$ in. for the camera used) g equal to a hundredth part of the focal length of the lens Figs. 1, 3 and 4). These two vertical scales must be ad- d so that the center-point marked on each strip will fall in center of the camera-field or film, and a straight line con- ng these two points on the negative, after exposure, will establish the horizon-line. To the top of the camera-box 60-second levels at right angles to each other are adjusted a sight alidade is attached, in such a manner that its di- on of sight coincides with a line extended from the center ne lens to the zero or center-point of the horizontal scale e the camera. The bottom of the camera-box is fitted three leveling-screws, adjustable to the transit-tripod. To e the camera more serviceable, and to eliminate the neces- of a transit at the camera-stations, a transit-plate with ver- may also be fitted to the camera-box; and from this all

necessary angles can be read. From the photographs taken with a panoramic camera fitted with the above attachments it is possible to determine the positions, both horizontally and vertically, of all points within the area photographed.

III. Adjustment.

To determine whether the zero of the horizontal scale corresponds to the point of sight taken with the alidade, and also to ascertain whether the center-marks of the vertical scale representing the horizon-line are correctly placed, the procedure is as follows:

With the transit set up over a station from which a broad view may be obtained, sight on some prominent point and then take angular readings to other points and note several points of equal elevation to the station occupied. Set up the camera over this station, sight the attached alidade on the first point sighted with transit, and then take view. After development of the negative a comparison of the readings is made. If the zero of the horizontal scale does not fall directly over the point sighted with the alidade, shift the scale or alidade to the amount of difference indicated on the negative. If the points of equal elevation noted by the transit-readings do not fall on the horizon-line represented on the vertical scales, it is a simple matter to adjust either the scales or the levels until such is the case. To make this latter adjustment perfect may require several trials.

A simpler way to adjust the vertical scales, and a test that should be made from time to time in the field, is to set up the camera on the shore-line of a lake or at sea-level and make an exposure; the horizon-line indicated by the vertical scales should coincide with the surrounding shore-line of the lake or the horizon-line of the sea. If this is not the case, the scales should be adjusted until harmony exists.

With the present camera adjustments for determining the parallelism of the film to the axis on which the lens revolves cannot be made. A camera, however, is under construction in which this and other adjustments will be possible.

IV. FIELD-WORK.

'he accuracy and detail of the mapping depend largely upon precision of the base work, the number of camera-stations upied, and also the scale of the map. If a careful primary secondary triangulation of an area has been made, and nerous stations have been established, one could enter the l with camera alone and complete the field-work of a fairly urate topographic survey of that section in the same man- one would use a plane-table, but in a much shorter time. th the plane-table, most of the plotting is done in the field, n the camera the same work is done in the office; with the ne-table one can occupy but one station at a time; with camera, when plotting, one can practically occupy two or e stations at once and in this way simultaneously, from or more points of view, see the area to be mapped. This er circumstance is a strong factor in the identification of nts. Again, when a mere reconnaissance-survey is to be de, the topographic work may be accomplished with the nera while the triangulation is advancing. By so doing, not y time is saved, but much information regarding the timber- its and density of growth, and in some instances character- cs in land-sculpture and geologic structure, may afterwards obtained from the photographs, all of which would be tted by the usual method of mapping. For reconnaissance- k the camera is, therefore, especially to be recommended.

ll the triangulation-stations occupied by the transit should be occupied by the camera, thus securing a check on the ngulation. In selecting camera-stations, those taken at low moderate elevations are of greatest service as aids in draw- the topographic details, while those at high elevations are t for advancing the triangulation. In each case, however, necessary to have three previously-determined points in the l of view, preferably at wide angles, which may be sighted n the alidade on the camera from the station occupied, so t, from the angular readings taken, the position of the nera-station can be determined. The elevations of these in- nediate stations are noted from barometric readings and r are checked by determinations from the elevations of wn points included upon the negative. The elevations of triangulated points, where the transit is employed, are de-

termined in the usual way by vertical angle-readings upon points of known elevation or at sea-level.

It is hardly necessary to mention the advisability of erecting monuments or signals upon all stations so that they may be sighted from other and new stations.

V. Plotting Maps from Photographs.

It is first necessary to develop the film-negatives—the best plan being to do so in the field, so that a defective negative may be replaced by taking another view at once. Such failures, however, are not probable. During the past summer I took 200 views under all conditions of weather, and not one of the negatives was defective. They were developed in the field, for the most part within a day or two after exposure; and several dozen, left undeveloped until my return to the office, some three months later, were developed with equally good results.

A preliminary plotting of triangulation-points and camera-stations on the map should be done in the field, and traverses of trial- and shore-lines should be added. This is recommended to prevent the introduction of "holes" in the map, that is, small areas which cannot be accurately plotted in the office, because they were sighted from but one station, or were otherwise neglected. In the office, to facilitate the topographic plotting, enlargements are made from the negatives, which were 5 by 12 in., to prints, 10 by 24 in. in size. As the horizontal and vertical scales are photographed on the negative at the time of exposure, no error is introduced by making these enlargements. The uneven contraction and expansion of photographic paper is often a cause of error in plotting; but if care is taken in developing and drying the prints, and if they are all made on the same kind of photographic paper, this error is only a slight one. To eliminate it, however, plotting may be done directly from the negatives.

Having established a map-scale and plotted the triangulation-points, the camera-stations should next be determined. This is done by the three-point method, by which the angular readings to three or more determined points, taken from the station, either by a transit or read from the photograph, are plotted on a piece of tracing-paper. The lines indicating the angular

ings are placed over the respective points and the positions e camera-stations thus located.

ie camera-stations being plotted on the map, one may next eed to select numerous points common to two or more s from different stations, and to plot their positions by lines tersection representing their respective bearings read from iorizontal scale on the photograph.

facilitate this work a T-square 1 ft. long is made, the cal arm being divided to correspond with the vertical scale ie photograph. The photograph is adjusted to a drawing-d 12 by 24 in. in size, so that the center-line of the ver- scales coincides with the center-division marked on the uare. (See Fig. 7.) On the map a line is drawn from the ective camera-station in the direction sighted at the time photograph was taken, and by the aid of a protractor, and lar readings taken with the T-square from the horizon-ale, the directions of all points may be plotted. When the ion of any point has been determined by the intersection s lines of direction from two or more stations, its relative tion may be obtained by multiplying the number of divisions ie T-square above or below the center-line by the horizon-istance of the point, measured in feet, and dividing by 100, e divisions represent hundredths of the focal length for photograph. (The focal length or radius for the enlarged ramic photograph is obtained from the formula $r = \frac{2}{\pi} H$, e $H = \frac{1}{4}$ of the circumference of circle or distance meas- between 90° on the horizontal scale of the enlarged pho-aph). This result is added to the elevation of the camera-on above sea-level and the sum is the elevation of the point. , if a mountain-peak is 20 divisions above the center- on the vertical scale and the horizontal distance measures) ft., then its relative altitude is $\frac{20 \times 8{,}000}{100} = 1{,}600$ ft.; added to the elevation of the camera-station gives the total tion of the peak above sea-level. (In computing the ele-n of distant points the correction for curvature of the earth refraction should be added.)

hen plotting, the photographs showing the same area from

two stations are set up on the drawing-table, as shown in Fig. 7, and points seen from both stations are numbered directly on the photographs, the same numbers being used to indicate the points on the map.

The protractor used in this work was of card-board, 10 in. in diameter, with the central portion cut out. This was oriented on the map over the camera-station and made fast with thumb-tacks. A narrow scale, 10 in. long, divided into units of the map-scale, and fitted with a pin-point at the 0 mark, served as a protractor-arm as well as a scale for measuring the horizontal distance. This arrangement is shown in Fig. 7.

To obviate the necessity of orienting the protractor for each station, and to facilitate plotting, a parallel movable engineers' protractor may be used to advantage. As this protractor has a fixed orientation it is necessary to determine the azimuth for

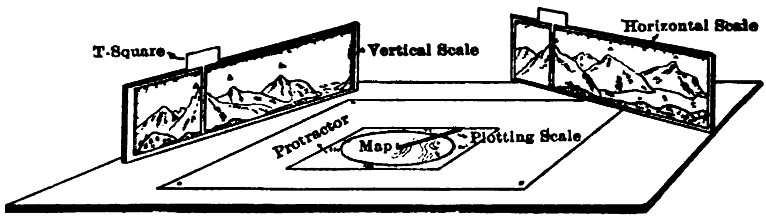

FIG. 7.—SKETCH SHOWING ARRANGEMENT FOR PLOTTING OF MAP FROM PHOTOGRAPHS.

the zero-point on each photograph and to adjust the horizontal scale so that the direct azimuth readings may be taken from the photographs.

After a sufficient number of characteristic points have been plotted upon the map and their elevations noted, it is a simple procedure to introduce the lines of contour by the aid of the photographs. By using the above method an experienced topographic draftsman can complete an expressive map of the land-sculpture of an area from photographs in the office.

Both the plotting of points and the determination of their elevation may be done graphically as follows:

Construct a framework, consisting of 3 bars, equal in length (about 5 in.), attached to a curved strip of metal sheeting, of the size of the photograph, shown in Fig. 6. At the junction of the 3 bars representing the radii of the arc, attach a pin-point; the distance from pin-point to outer surface

ırved metal sheet should be equal to the determined focal h for the photographs from which the map is to be plotted. he photograph, project the points to be plotted to its base om of photograph). Fasten this photograph face out to ramework and place pin-point on the same over the sta- point on the map and then orient it in the photo direc- Project the points at base of photograph on the map, ating them by numbers corresponding to those on the pho- ph. In this manner the direction of each point is plotted tly from the photographs.

ascertain the altitude of points on the photograph rela- to the camera-station we have this proportion: The meas- distance, y, of point on photograph above or below the

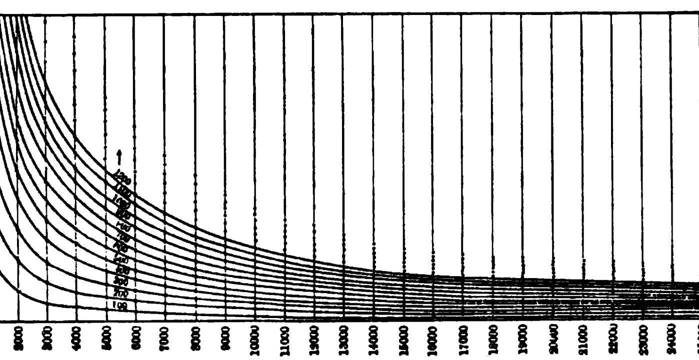

FIG. 8.—DIAGRAM FOR DETERMINING ELEVATION OF POINTS.

ontal line is to the determined focal length for photo- ı, f, as the elevation of the point E above or below camera- n is to its horizontal distance, x, from the camera-station. proportion, $y : f = E : x$, gives $xy = Ef$, which is the ıla for a hyperbola in which x and y are the variable and d f the constant factors.

construct the diagram, divide the horizontal axis of a ngular co-ordinate-system into units of the map-scale; this, at points representing intervals of 1,000 ft. horizontal nce, erect vertical lines, on which the computed lengths of each 100 ft. elevation at the respective horizontal dis- s are indicated. By connecting the points which repre- the same elevation on these vertical lines of the diagram, rbolic curves are formed (see Fig. 8), each curve represent-

ing points of equal elevation at their respective horizontal distances. With a diagram thus constructed, we can scale the horizontal distance of a point directly and also measure its elevation, relative to the camera-station, by transferring, preferably with a pair of dividers, the distance *y* from the photograph to the diagram, directly above the point indicating its horizontal distance. The practicability of this graphic method has not been tested; but, though it may lack in accuracy, it will undoubtedly facilitate and greatly shorten the work of plotting the maps.

VI. Accuracy of Method.

The two photographs, Figs. 3 and 4, may serve to illustrate the panoramic method. These views are of Rendu Glacier, in Glacier Bay, Alaska. The peaks with a triangle over them are triangulation-points determined in 1892 by Professor H. F. Reid, whose map was used as a base. The two camera-stations occupied, on opposite sides of the inlet, were located by transit-readings on the triangulation-points. These points and stations were first plotted on the accompanying map, Fig. 5; the positions of numerous points represented on each photograph were determined by the above method, and a map sufficiently accurate for the intended purpose was thus constructed.

The maximum difference in elevation of a point measured on photographs from two or more camera-stations seldom exceeds 10 ft. for a horizontal distance of one mile. Determinations of the two triangulation-points shown in the accompanying views gave the following results:

Triangulation Pt. 1, from Sta. A. Horizontal dist. = 31,500 ft. Elevation = 4,934 ft.

Triangulation Pt. 1, from Sta. B. Horizontal dist. = 25,000 ft. Elevation = 4,906 ft.

A difference of 28 ft. in a distance of 5 miles.

Triangulation Pt. 2, from Sta. A. Horizontal dist. = 14,500 ft. Elevation = 4,868 ft.

Triangulation Pt. 2, from Sta. B. Horizontal dist. = 18,400 ft. Elevation = 4,842 ft.

A difference of 26 ft. in a distance of 3 miles.

I. ADVANTAGES OF THE PANORAMIC CAMERA METHOD.

›tography cannot replace instrumental topographic sur-
g, and, in many areas, cannot be used at all; yet experi-
ıas shown it to be a valuable adjunct in nearly all sur-
The topographic features of an area will necessarily
nine the method to be employed in its mapping. A flat,
g plain cannot be mapped in the same manner as a rug-
nountainous region, or a heavily timbered area where
views cannot be obtained. Areas of bold topography
harp or often rounded summits and little timber, such as
ncountered in the western States and Alaska, are most
ıtageously mapped by the camera method. To make a
-table survey of such an area requires the expenditure of
time in the field in constructing the map, and the ex-
of a large field-party. The conditions of weather which
along the western coast and in Alaska are such that the
ıits are enveloped in a cloud of fog, often during the
er portion of the day. When the view is clear for a short
only, a photograph of the surrounding country may be
, thus completing in a fraction of an hour the work at a
n which would require many hours or even days by the
-table method. It should be noted that alidade-reading
ıote-taking from a mountain-top in Alaska on the usual
foggy day, with a still colder wind blowing, is by no
s comfortable, and even the best topographers are inclined
rry their work. In this manner, some portions of an area
ıore carefully mapped than others. Having the photo-
ıs of an area with the bearings of all points registered
tly above them, the plotting of the map can be done with
agreeable surroundings in the office, where all conven-
s are at hand, and thus a map can be constructed of more
rm accuracy, and with as much detail as desired. If this
similar graphic method of mapping were applied in certain
ns a great deal would be saved in both time and expense,
ared with topographic surveying as generally practiced.

VIII. Comparison of Panoramic Camera Method with Other Photographic Methods.

In the present practice of photo-topography a photo-theodolite or similar instrument is employed. This consists of a specially prepared plate-camera with a fixed-focus lens adjusted to a horizontal transit-circle. Attached to the top of the camera-box is a telescope with vertical circle for the reading of vertical angles. At the back of the camera and directly in front of the sensitized plate are two cross-hairs, the one forming the vertical center-line and the other the horizon-line. Inside the camera is a flat magnetic needle attached to a disk, to which a vertical transparent scale is adjusted. This revolves directly in front of the sensitized plate so that when the exposure is made the magnetic bearing of the view is photographed upon it. With this instrument a group of eight views are necessary to complete a panorama, and the angular direction of each view must be read on the horizontal transit-plate and noted. Another disadvantage of the photo-theodolite is its weight and bulk, besides the limited number of plates which may be taken on a trip and the necessity of reloading the plate-holders. With the panoramic camera the daylight-loading films are used, which eliminate the danger of breakage, lessen the weight to be carried and permit development in the field directly after exposure, in a daylight developing-tank.

The plotting of a map from the views taken by the photo-theodolite is a long and tedious process (though possessing no special difficulties), and the office work necessary to complete the map is many times greater than that required for the same amount of mapping by the panoramic camera.

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American Institute of Mining Engineers.

PUBLISHED BY THE AMERICAN INSTITUTE OF MINING ENGINEERS

Editorial Office at 29 West 39th Street,

NEW YORK, N. Y.

Dr. Joseph Struthers.

MUNICIPAL EXPLOSIVES COMMISSION OF THE CITY OF NEW YORK. *Regulations Governing the Manufacture, Storage, Sale and Use of Explosive and Combustible Substances.* 181 p. 12mo. New York, 1908.

AERO CLUB OF AMERICA. *Constitution, By-Laws, List of Members,* 1908. 12mo.

WOOLSON, I. H. *Investigation of the Thermal Conductivity of Different Concrete Mixtures and the Effect of Heat Upon their Strength and Elastic Properties.* p. 404–420 p. il. 8vo. n. p., n. d.

Frederick W. Taylor.

Subsidios para o Estudo das Pozzolanas e sur Applicacão nas Construcções. 77 p. tab. 8vo. Lisboa, 1907.

J. B. Tyrrell.

TYRRELL, J. B. *Concentration of Gold in the Klondike.* p. 343–349 p. 8vo.

——— *Cretaceous of Athabasca River.* 4 p. 8vo.

——— *Foraminifera and Radiolaria from the Cretaceous of Manitoba.* p. 111–115. 8vo.

——— *Glacial Phenomena in the Canadian Yukon District.* p. 193–198, map. 8vo.

——— *Glaciation of North Central Canada.* p. 147–160.

——— *Is the Land Around Hudson Bay at Present Sinking?* p. 200–205.

——— *Natural Resources of the Barren Lands of Canada.* p. 126–138.

——— *Pleistocene of the Winnipeg Basin.* p. 19–28. 8vo.

——— *Post-Tertiary Deposits of Manitoba and the Adjoining Territories of Northwestern Canada.* p. 395–410. 8vo.

——— *Some Suggested Amendments to the Yukon Mining Law.* 8vo.

——— *Three Deep Wells in Manitoba.* p. 91–104. 8vo.

——— *Yukon Mining Laws.* 9 p. 8vo.

U. S.—Bureau of the Mint.

U. S.—MINT, BUREAU OF. *Annual Report of the Director,* 1907. 8vo. Washington, 1907.

U. S.—Commissioner of Education.

U. S.—EDUCATION, COMMISSIONER OF. *Report,* 1906. Pt. 2. 8vo. Washington, 1908.

S.—Geological Survey.

U. S.—GEOLOGICAL SURVEY. *Mineral Resources*, 1906. 8vo. Washington, 1907.

rein Deutscher Eisenhüttenleute.

Handelspreise von Kohle und Eisen in den jahren, 1885-bis 1907. unp. tab. 8vo. Düsseldorf, 1908.

Gemeinfassliche Darstellung des Eisens. xvi, 254 p. 8vo. Düsseldorf, 1907.

llaroo & Moonta Mining & Smelting Company, Ltd.

WALLAROO & MOONTA MINING & SMELTING COMPANY, LTD. *Wallaroo and Moonta Mines.* 25 p. pl. 8vo. Wallaroo, 1907.

Waller.

Zeitschrift für Anorganische Chemie. Vol. 1–29. 8vo. 1892–1902.

n Wiley & Sons, New York.

BEARD, J. T. *Mine Gases and Explosions.* xvii, 402 p. il. 8vo. New York, 1908.

LOW, A. H. *Technical Methods of Ore Analysis.* Edition 3. xii, 344 p. il. 8vo. New York, 1908.

KARAPETOFF, V. *Experimental Electrical Engineering and Manual for Electrical Testing.* xxxi, 790 p. il. 8vo. New York, 1908. Price, $6.

NORRIS, H. H. *An Introduction to the Study of Electrical Engineering.* v, 404 p. il. 8vo. New York, 1907. Price, $2.50 net.

vid Williams Company.

NEUBECKER, WILLIAM. *Mensuration for Sheet Metal Workers.* 51 p. il. 8vo. New York, 1907.

SYLVESTER, W. A. *Modern Carpentry and Building.* Edition 2. 276 p. il. 8vo. New York, 1907.

F. Williams.

DE BEERS CONSOLIDATED MINES, LIMITED. 19*th Annual Report.* f°. Kimberley, 1907.

NEW EXCHANGES.

Central. Edited on behalf of the City and Guilds of London Central Technical College. Quarterly. v. 4, Nos. 11-date.

ITÉ CENTRALE DES HOUILLÈRES DE FRANCE. *Circulars.* Dec., 1907-date.

GEOGRAPHICAL SOCIETY OF PHILADELPHIA. *Bulletin.*

SOCIÉTÉ INDUSTRIELLE DE L'EST. *Bulletin.*

SOCIEDAD COLOMBIANA DE INGENIEROS, Bogota. *Annales.*

Stone. Continuation of old periodical, which suspended publication in Dec., 1903. Continued under new management from April, 1907.

PURCHASES.

BJÖRLING, P. R. and GISSING, F. T. *Peat: Its Uses and Manufacture.* xii, 173 p. il. 8vo. London, 1907.

BRUSH, G. J. and PENFIELD, S. S. *Determinative Mineralogy,* with an Introduction on Blowpipe Analysis. Edition 16, 307 p. 8vo. N. Y., 1907.

CHEMICAL SOCIETY, LONDON. *Journal.* v. 27-91.

GEIKIE, ARCHIBALD. *Text-Book of Geology.* Ed. 4, 2 vols. London, 1903.

HUGHES, H. W. *Text-Book of Coal Mining.* Ed. 5, xiv, 563 p. il. pl. 8vo. London, 1904.

KERR, G. L. *Practical Coal Mining.* Ed. 4, x, 504 p. il. 8vo. London, 1905.

LEDEBUR, A. *Leitfaden für Eisenhütten-Laboratorien.* ix, 130 p. il. 8vo. Braunschweig, 1902.

Who's Who, 1908. 8vo. London, 1908.

TRADE CATALOGUES.

Realizing the value of trade catalogues in a technical library, the Library Committee of the American Institute of Mining Engineers has signified its approval of a plan to strengthen the library along this line. Manufacturers are therefore asked to place the Library of the American Institute of Mining Engineers on their regular mailing-lists for Trade Catalogues on Metallurgical and Mining Machinery, Mine and Miners' Supplies, Metallurgical Laboratory Equipments, Assayers' and Chemists' Supplies, etc., and also Technical Industrial Catalogues.

All contributions will be acknowledged in the *Bi-Monthly Bulletin.*

ADAMSON-STEPHENS MFG. CO., Aurora, Ill. Conveying and Transmission. Vol. 4, No. 1, 1908; Vol. 3, No. 3, 1907.

ALLENTOWN ROLLING MILLS, Allentown, Pa. Pump Data. Nos. 14-20.

RICAN SPIRAL PIPE WORKS, 39 Cortlandt St., New York, N. Y. Forged and Rolled Steel Pipe Flanges. June, 1907.

RICAN STEEL COMPANY, Pittsburg, Pa. American and Patented Wrought-Steel Floor Plates.

SDELL COMPANY, Park Row Building, New York, N. Y. El Oro Tube Mill Lining (Catalogue H).

ELECTRIC DRILL COMPANY, 115 Broadway, New York, N.Y. (*Bulletin* No. 201, July, 1907.)

NEER COMPANY, 111 Broadway, New York, N.Y. Balanced Draft System.

ONE DRILLING Co., Orrville, Ohio. Drilling *vs.* Shaft-sinking. Vol. 2, Nos. 1 and 2, 1908.

BERLAND TELEPHONE & TELEGRAPH COMPANY, Nashville, Tenn. *Annual Report*, 1907.

SCHMIDT THERMIT COMPANY, 90 West St., New York, N. Y. Shop Instructions for the Use of Thermit in Repair Work. 8vo. 1908.

DINGE CONICAL MILL COMPANY, Exchange Place, New York, N. Y. Advance sheet of . . . for fine and coarse, wet or dry grinding.

INS BROS., 71 John St., New York, N. Y. Extra Heavy Valves.

REY MANUFACTURING COMPANY, Columbus, Ohio. Centrifugal Fan for Mine Ventilation.

FEL & ESSER COMPANY, 127 Fulton St., New York, N. Y. (General Catalogue, 1907.)
Solar Ephemeris for 1908.

LATTA & MARTIN PUMP Co., Hickory, N. C. Local and long distance pumping.

GOMERY & Co., 105 Fulton Street, New York, N. Y. A few good tools attractively priced.

ER SPECIALTY COMPANY, 111 Broadway, New York, N. Y. Superheated Steam. Ed. 4. 1907.

BOILER Co., Pittsburg, Pa. Report of Tests on the Rust Water-tube Boiler, by Wm. Kent.

HWARK FOUNDRY AND MACHINE COMPANY, Philadelphia, Pa. Weiss Condensers for Turbine Installations.
— Weiss Condensers for Engine Installations.

SULLIVAN MACHINERY Co., 42 Broadway, New York, N. Y. (*Bulletin* 60 A, Feb., 1908.) Hammer Drills for Mining Work.

TAYLOR BROTHERS COMPANY, Rochester, N. Y. Verschoyle Patent Transit.

L. C. TRENT CONTINUOUS FILTER Co., Masonic Building, Reno, Nevada. Continuous Filtering and Straining Machines. (*Bulletin* No. 1.)

TRENTON IRON COMPANY, Trenton, N. J. Application of Wire Rope to Surface and Underground Haulage, etc. 1906.

——— Cable Hoist-Conveyors. 1906.

——— Directions for Erecting and Operating Bleichert Tramways. 1908.

——— Price Lists of Wire Rope and Fittings. 1908.

——— Transportation of Materials by Wire Cables.

——— Wire Rope and its Application to the Transmission of Power, etc.

——— Wire Rope Tramways, 1908.

——— Wire Rope Tramway Engineering, by S. S. Webber. 1907.

UNION IRON WORKS COMPANY, San Francisco, Cal. Low Sample Crusher and Sample Grinder.

——— The Merton Roasting Furnace.

YALE & TOWNE MANUFACTURING Co., 9 Murray St., New York, N. Y. Portable Electric Hoists.

WYCKOFF SUPPLY COMPANY, Robinson Building, Elmira, N. Y. Wyckoff Wood Pipe.

PROCEEDINGS OF THE ANNUAL MEETING.

the Annual Business Meeting of the Institute, held Feb. 908, the following persons were elected:

COUNCIL.

President.

(To serve for one year.)

HN HAYS HAMMOND,	New York, N. Y.

Vice-Presidents.

(To serve for two years.)

PARKE CHANNING,	New York, N. Y.
W. DENTON,	Painesdale, Mich.
HN B. FARISH,	Denver, Colo.

Secretary.

(To serve for one year.)

W. RAYMOND,	New York, N. Y.

Councilors.

(To serve for three years.)

R. CORNING,	New York, N. Y.
V. NORRIS,	Wilkes-Barre, Pa.
H. SHOCKLEY,	Tonopah, Nev.

DIRECTORS.

(To serve for three years.)

MES DOUGLAS,	New York, N. Y.
MES F. KEMP,	New York, N. Y.
BERT R. LEDOUX,	New York, N. Y.

RETARY'S NOTE.—The complete list of all officers of the Institute will be on p. iv. of this number of the *Bulletin.* The following explanation, first ed in *Bi-Monthly Bulletin*, No. 8, March, 1906, p. viii., is here repeated r to recall to old members, and convey to new ones, the relations of the verning bodies as determined by the Certificate of Incorporation of the te, and the Constitution and By-Laws adopted in accordance therewith. body legally responsible for the business management is the Board of nine ors (three elected annually to serve three years), which elects its own offi- This body, for reasons of practical convenience, is composed of well-known rs residing in New York City, and able to attend, without serious incon- ce or expense, the necessary meetings of the Board. The officers of this are legally the officers of the Institute. But, apart from business manage-

ment, the Board exercises no control over the election of members, or the professional and technical work of the Institute, except that its vote is required to elect honorary members, upon the recommendation of the Council.

The Council is a body constituted in all respects (except that it has no Treasurer) like the Council existing before the incorporation of the Institute, in January, 1905, and charged with all duties and powers, except those which the Board of Directors must legally perform. It elects members, appoints the times and places of professional meetings, and controls the publication and distribution of papers and volumes, etc. Its members (President, Vice-Presidents and Councilors) are elected by the members of the Institute, voting in person or by proxy, and after publication of the nominations received; and it is intended to represent, as far as practicable, both the professional and the geographical distribution of the membership. Consequently, whatever professional honor attaches to official position belongs to membership in the Council, rather than in the legal Board of Directors. This remark implies no disparagement of the members of the latter body, every one of whom has served, or is now serving, as a member of the Council. But it is only fair to explain that their election and continued reelection as Directors is simply a matter of legal convenience.]

Proposed Amendments to the Constitution.

Notice was given in writing, as required by Article XII. of the Constitution, of the following amendments, proposed for consideration at a future business meeting:

To Art. II. After the first sentence of this Article, add the following sentence:

"These classes may be sub-divided by the Council, according to profession, length of membership, nationality, or other conditions not inconsistent with the provisions of this article."

To Art. III. In the first line, substitute "fifteen" for "ten" dollars.

PROCEEDINGS OF THE BOARD OF DIRECTORS.

The following acts of the Directors are reported for the information of members:

At a meeting held June 20, 1907, Dr. Charles D. Walcott, Director of the U. S. Geological Survey, Washington, D. C., having been recommended by unanimous vote of the Council, was unanimously elected an Honorary Member of the American Institute of Mining Engineers, in recognition of his personal services to American geology, and of his generous coöperation with this Institute, to the *Transactions* of which he has not only himself made valuable contributions, but has also encouraged the preparation of such contributions by the members of the U. S. Geological Survey under his charge, his general policy in this respect having gone so far as to permit the preliminary publication by the Institute of important results reached by the geologists of that Survey, even before their final and full publication as public documents. This wise and generous course has not only brought the U. S. Geological Survey into intimate and sympathetic relations with the mining industry of the world, but has also enriched the *Transactions* of the Institute, especially in the department of the science of ore-deposits, with many valuable papers.

At a meeting held Jan. 14, 1908, Mr. Charles Kirchhoff was unanimously re-elected a Trustee of the United Engineering Society, to serve for a second term of three years.

At a meeting held Feb. 18, 1908, directly after the adjournment of the annual meeting of the Institute, the following officers were elected for the ensuing year: *President*, James Gayley; *Vice-President*, James Douglas; *Secretary*, R. W. Raymond; *Treasurer*, Frank Lyman.

FINANCIAL STATEMENT.

The following statement of receipts and disbursements from Jan. 1 to Dec. 31, 1907, is published by authority of the Board of Directors.

RECEIPTS.

Balance from statement of January, 1907,		$1,238.78
Annual dues,*	$37,483.85	
Life memberships,	2,460.00	
Initiation fees,	3,010.54	
Binding of *Transactions*,	3,585.65	
Sale of publications,	3,504.35	
Electrotypes,	35.90	
Miscellaneous receipts,	330.71	
Advertising,	3,536.47	
		53,947.47
Interest on bonds and deposits,		1,132.68
Reimbursement from Special Fund for balance of installments of principal and part of interest paid to the United Engineering Society on mortgage in 1906, now reimbursed,		13,400.00
Reimbursement from Library Fund for library additions (1907),		218.67
		$69,937.60

DISBURSEMENTS.

Printing Vol. XXXVII. of the *Transactions*, *Bi-Monthly Bulletin* and extra pamphlets,	$11,567.18	
Printing circulars and ballots,	131.25	
Binding Vol. XXXVII. of the *Transactions*,	3,287.27	
Binding miscellaneous volumes,	425.33	
Binding of exchanges,	300.00	
Engraving and electrotyping,	716.85	
Secretary's department, including clerks, stenographers and expenses of editing and proof-reading,	10,219.29	
Treasurer's department, including collection of dues, shipping, etc.,	5,629.63	
Librarian and assistants,	1,534.00	
Postage,	3,721.57	
Stationery,	630.22	
Express and freight charges,	1,672.94	
Telephone,	241.66	
Telegrams, cables, carfares, etc.,	69.33	
Office supplies and repairs,	153.72	
Refunding over-payments,	39.61	
Insurance premiums,	246.43	
Collection charges,	36.83	
Extra clerical assistance,	156.75	
Special stenographers and expenses of meetings,	669.14	
Auditing,	125.00	
Advertising, expenses and commissions,	1,495.58	
Office cleaning and sundry expenses,	31.70	
		43,101.28
Interest at 4 per cent. on $130,000 principal of land mortgage on 29 West 39th St.,	5,200.00	
Quota of current expenses of building 29 West 39th St.,	10,000.00	
		15,200.00

* $17,470 of this amount has been applied to subscriptions to the *Bi-Monthly Bulletin* in accordance with post-office regulations.

ial editing, compiling, printing and binding special ition, Index Vols. I. to XXXV.,		$3,625.90
for part of offices, 99 John St., during January, bruary and March,	$250.00	
ge of *Transactions*,	129.45	
		379.45
ary additions (expenditure from appropriation of 00),		473.73
e improvements, including shelving,		796.89
iture, etc., amount expended of appropriation of ,000,		1,519.39
dry fittings and incidentals,		534.21
nce,		4,306.75
		$69,937.60

NEW YORK, N. Y., February 4, 1908.

e have examined the above statement, compared it with the books and chers and find same correct.

(Signed) BARROW, WADE, GUTHRIE & Co.,
Certified Public Accountants.

PROCEEDINGS OF THE COUNCIL.

The following report is published for the information of the members:

Meetings.

Two meetings for the reading and discussion of papers, etc., have been held during the year 1907—namely, the Ninety-second meeting, held April 16 to 20 in New York, N. Y., and the Ninety-third meeting, held July 23 to 30 in Toronto, Canada.

The proceedings of these meetings, including descriptions of the entertainments and excursions connected therewith, have already been published and distributed to the members of the Institute; the New York meeting in *Bi-Monthly Bulletin*, No. 15, May, 1907, pp. 541 to 559, and the Toronto meeting in *Bi-Monthly Bulletin*, No. 17, September, 1907, pp. 847 to 875. In addition to these "Proceedings," there were also published in *Bi-Monthly Bulletin*, No. 15, May, 1907, an illustrated description of the United Engineering Society building (pp. vi. to xxvi.), and a record of the exercises attending its dedication, including the addresses of Andrew Carnegie, Arthur T. Hadley, Samuel Sheldon, Frederick R. Hutton, John Hays Hammond, and T. C. Martin (pp. xxxviii. to lxv.).

At the New York meeting, 43 papers and discussions were presented, and the names of 297 members and guests were registered at the Institute headquarters; this number, however, does not represent all who were present at the sessions and excursions. At the Toronto meeting, 23 papers and discussions were presented. The number of members and guests registered at the Toronto headquarters was 191, which doubtless does not include the names of all who were present at the sessions, or took part in the numerous excursions and visits around Cobalt.

Publications.

Transactions.—Volume XXXVII. of the *Transactions*, an octavo of 1,044 pages, comprising 51 papers and discussions presented during the year 1906, was issued and distributed

early in July, only a few weeks later in the year than the corresponding appearance of Volume XXXVI. With the exception of the index, and a few papers, the final revised proofs of which have not yet been received from the authors, the material for Volume XXXVIII., comprising in all about 1,050 pages, is in the hands of the printer. It is expected that the bound volumes will be ready for distribution in June or July, 1908.

Bi-Monthly Bulletin.—Six numbers of the *Bi-Monthly Bulletin* (Nos. 13 to 18), containing the technical papers of the Institute and announcements of general interest to the members of the Institute, such as Library accessions and requirements, lists of new members and associates, lists of proposed members and associates, changes of address, deaths of members, progress on the United Engineering Society building, etc., have been published and distributed promptly throughout the year 1907. The number of pages occupied by technical papers, and "subject and author" index, amounts to 1,030, to which are to be added 252 pages of announcements, and 128 pages of advertising matter, making a total of 1,510 pages of printed matter.

The management of the *Bi-Monthly Bulletin*, Volume XXXVII., and the forthcoming Volume XXXVIII. of the *Transactions* continues in charge of Dr. Joseph Struthers, the Assistant Secretary and Editor.

Index.—A complete analytical and alphabetical Index of Volumes I. to XXXV. (inclusive) of the *Transactions* was issued and distributed to subscribers in November, 1907. The work consists of 700 pages, bound in cloth or half morocco. The magnitude of the Index, involving the collection, sorting, classification and completion of many thousand titles, names and cross-references, can only be fully appreciated by those who have done work of similar character. Comparatively few complete sets of *Transactions* are in the possession of the members of this Institute, and the number of such complete sets remaining on hand is very small. The volumes have never been stereotyped, and it is not likely that any of them will be reprinted. The Institute maintains, at more than a hundred important mining centers throughout the world, free sets of its *Transactions*, open for consultation, without fee, to all suitable applicants.

To those who do not possess a complete set of the *Transactions*, this Index is of special value, since it shows not only the contents of all the volumes, but also, from the table of contents, the papers contained in any one volume. Moreover, members not infrequently send for publication valuable professional papers in which previous contributions to the *Transactions*, directly or indirectly dealing with the same subjects, are ignored. The author of an Institute paper should recognize what his fellow-members have done before him in the same line, which he cannot do unless he is acquainted with the contents of the back volumes of the *Transactions*. In this connection, the Index will prove indispensable. Finally, the issue of this Index is part of the plan to render available to those members at a distance the privilege of consulting by correspondence books and periodicals in the combined libraries of the three founder societies (now exceeding 50,000 volumes of scientific and engineering works and 450 current technical journals and magazines), in order to obtain copies or abstracts of text and drawings.

The index-volume, of which an edition of 1,600 was printed, has not been stereotyped; the price of the cloth-bound copy is $5; of the half-morocco bound, $6.

Membership.

Changes in membership have taken place during the year as follows:—1 honorary member (previously on the regular list of members), 291 members and 12 associates have been elected; 1 member has been elected an honorary member and 12 associates have become members; the deaths of 44 members and 4 associates have been reported; 43 members and 7 associates have resigned; and 63 members and 4 associates have been dropped from the roll by reason of non-payment of dues, loss of correct address, etc.* These changes are shown in the accompanying table.

The total membership on January 1, 1908, was 4,191, as compared with 4,048 on January 1, 1907—a net gain for the year of 143 members.

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* Many of these, no doubt, will be reinstated, as has been the case in former years.

Membership of the American Institute of Mining Engineers, Jan. 1, 1908.

	Honorary Members.	Members.	Associates.	Totals.
Membership Dec. 31, 1906	11	3,858	179	4,048
Gains: By Election		291	12	303
Change of Status	1	12		13
Reinstatement		3		3
Re-election		2		2
Losses: By Resignation		43	7	50
Change of Status		1	12	13
Dropping		63	4	67
Death		44	4	48
Total gains	1	308	12	321
Total losses		151	27	178
Membership Dec. 31, 1907	12	4,015	164	4,191

The list of deaths reported during the year 1907, comprises the following names, the figures in parentheses indicating the year in which the persons named were elected to membership:

Members and Associates.—Thomas T. Baker (1887), Charles W. Benton (1897), Carl W. Bildt (1886), John Blatchford (1897), John Blue (1888), William R. Boggs, Jr. (1882), George L. Bradley (1874), T. Forster Brown (1886), E. E. Burlingame (1882), Chauncey E. Butler (1896), George Devinny (1903), George H. Evans (1898), J. K. Eveleth (1887), A. W. Fiero (1886), William W. Garrett (1893), William Glenn (1881), George B. Hanna (1887), B. J. Harrington (1877), Frank J. Hearne (1874), Christopher Henne (1900), George C. Hewett (1883), Charles J. Hillard (1888), Karl Howard (1898), Thomas J. Hurley (1899), H. E. Ingram (1894), Thomas E. Johns (1904), William J. Johnston (1901), James F. Jones (1888), Winfield S. Keyes (1872), Gustavus W. Lehmann (1892), Walter Leisenring (1891), William H. Long (1882), Frederick W. Mathews (1904), Robert S. Mercur (1900), Charles A. Molson (1887), William G. Neilson (1872), Louis Pelatan (1894), Alfred M. Rock (1904), George W. Rose (1904), Gilbert C. Simpson (1902), Thomas W. P. Storey (1906), Sidney Thow (1902), Henry T. Townsend (1879), Jean A. Variclé (1905), John A. Walker (1878), Eugene B. Willard (1900), Lewis Williams (1883), James W. R. Young (1891).

Of these, William G. Neilson has been made the subject of a special Biographical Notice, printed in *Bi-Monthly Bulletin*, No. 16, July, 1907, p. 653.

REPORT OF THE UNITED ENGINEERING SOCIETY.

The following financial report of the Treasurer of the United Engineering Society is published for the information of members:

NEW YORK, February 15, 1908.

To the Board of Trustees, United Engineering Society:

I beg to submit herewith the report of the Treasurer as of December 31, 1907.

Your attention is called to the fact that the resources and liabilities, receipts and disbursements statements cover all the financial transactions of the United Engineering Society from its organization up to December 31, 1907.

The income and expenses of operating the building during the whole operating period from December 15, 1906, to December 31, 1907, somewhat in excess of twelve months, are given.

Included in the expenses, amounting in all to $52,647.11, will be found an item entitled "Building Equipment (construction account)." The expenditures under this item were not made for the operating expenses of the building, they represent a construction account, properly speaking, covering expenditures for furnishings and equipment of the building. The Founders' Agreement specifically provides for this class of expenditure under the provision that the Founder Societies shall each be liable for a charge not to exceed $200,000 of principal, which shall include the land and building completed and ready for occupancy, together with the "furnishings, equipment and personal property therein."

Certain details of equipment are yet to be supplied, and it is proposed in the near future to call upon the Founder Societies for an assessment on their respective land and building funds to cover this item of building equipment. Such action would enable the item of $10,039.85 to be transferred to the income account and reduce correspondingly the assessment

which it would be necessary to make on the Founder Socie-ies to cover the operating expenses for 1908.

he actual operating expenses for the period December 15, 1906, to December 31, 1907, have been		$33,126.41
or including furniture and fixtures, amounting to . . .		1,307.41
we have a total operating cost of the building for the above period of		$34,433.82
is includes an expenditure for telephone service of for which we are reimbursed by the occupants of the building, and also the cost of insurance premium for two years, only half of which should be charged to the 1907 operating account . . .	$1,174.76 1,087.24	
ere should, therefore, be deducted from the 1907 operating account a total of		$2,262.00
making the actual net cost of operating the building for the period of twelve and one-half months, including repairs and renewals, but exclusive of depreciation and reserve allowance, . . .		$32,171.82
, for the year—exactly 12 months— . . .		$30,884.94

It will also be noted that in compliance with the provisions the Founders' Agreement (Article 68) the Trustees have set ide, as a special fund to cover depreciation and reserve for 907, an amount of $5,000.

In the report submitted by Messrs. C. F. Scott, B. J. Arnold d Dr. S. S. Wheeler, under date of January 29, 1904, which as transmitted to the Founder Societies at the time, it was timated that the cost of operating the building would be proximately $27,039, exclusive of repairs and renewals d depreciation, which were estimated together at $2,961, aking a total then estimated of $30,000.

Attention is called to the fact that we have still available occupied space to the extent of the equivalent of one entire fice floor, which, if occupied, would produce an increased venue through assessments of approximately $11,000 per ar.

While each Founder Society occupies and is assessed for one hole floor, some of this space would be available for other nants should all the other office space become occupied.

The assessments paid by each of the Founder Societies cupying one entire office floor were $10,000 per year. In dition to this each Founder Society bears its burden of inrest charges, amounting annually to $7,000, a total cost of

$17,000, exclusive of charges for any occupancy of the auditorium or meeting rooms.

At the present rate of assessments for office space, the Associate Societies pay for similar accommodations at the rate of only $8,868 per year.

Even if it be assumed that the Founder Societies alone should bear the pro-rated charges for the occupancy of the Library floors, their total assessments, on the basis of the Associates' assessment, should be only $14,780 per year, instead of $17,000, the amount they have actually paid the past year.

It should be noted that many of the Associate Societies did not move into their quarters until considerably after January 1, 1907, and the Income Account does not, therefore, represent a full year of occupancy.

It will be seen, therefore, that as long as there is unoccupied space in the building the burden which the Founders' Societies will have to bear will be considerably in excess of the corresponding assessments which are being charged to the Associate Societies. Attention is also called to the comparatively small use of the Auditorium, as shown in the report of the Building Superintendent.

It is suggested that further efforts be made to induce other Societies to occupy the office space still available, and to secure a larger utilization of the Auditorium and meeting rooms. When such larger utilization shall be made of the exceptional facilities offered by our building, the burden of expense which the Founder Societies are now called upon to bear will be notably reduced, and the cost to them of their office facilities will be not greater than the rental of similar office space elsewhere, while the advantages accruing to each Society from joint occupancy of the building will be of inestimable benefit to every member.

Respectfully submitted,
(Signed) J. W. LIEB, JR.,
Treasurer.

BALANCE SHEET, JAN. 1, 1908.

Assets.

eal estate, land,	$ 540,000.00	
eal estate, building,	1,050,000.00	
uilding equipment (construction account),	10,039.85	
urniture and fixtures,	1,307.41	
ccounts receivable,	1,950.00	
etty cash,	500.00	
sh, bank balance,	6,507.87	
		$1,610,305.13

Liabilities.

int balance of mortgage (land),	$ 292,000.00	
I.E.E. payments in liquidation of mortgage on land,	99,000.00	
S.M.E. payments in liquidation of mortgage on land,	99,000.00	
I.M.E. payments in liquidation of mortgage on land,	50,000.00	
I.E.E. equity in building,	350,000.00	
S.M.E. equity in building,	350,000.00	
I.M.E. equity in building,	350,000.00	
ilding equipment (construction account),	10,039.85	
rniture and fixtures,	1,307.41	
preciation and Reserve Fund,	5,000.00	
lance cash and accounts receivable,	3,173.44	
counts payable,	784.43	
		$1,610,305.13

STATEMENT OF RECEIPTS AND DISBURSEMENTS UP TO DEC. 31, 1907.

Receipts.

eliminary Founders' assessment,	$ 24,000.00	
count principal of mortgage,	248,000.00	
count interest of mortgage,	47,098.86	
		$319,098.86
fund account organization expense,	4,696.18	
fund account interest,	46.55	
fund account insurance,	387.50	
nation account dedication exercises,	403.25	
		5,533.48
essment Founders,	29,999.97	
essment Associates (offices),	9,134.22	
essment miscellaneous (meetings),	2,904.25	
ephone and miscellaneous receipts,	1,459.46	
		43,497.90
		$368,130.24

Disbursements.

ount principal of mortgage,	$248,000.00	
ount interest on mortgage,	58,798.86	
anization expense,	10,634.27	
		$317,433.13

Building equipment (construction account), . .	$10,039.85	
Furniture and fixtures, ...	1,307.41	
		$11,347.26
Operating account (cash disbursements), . . .	28,112.53	
Stationery and printing, ...	1,890.26	
Insurance (two years), ...	2,339.19	
		32,341.98
Balance, cash in bank, ...	6,507.87	
Petty cash, ...	500.00	
		7,007.87
		$368,130.24

OPERATING INCOME AND EXPENSES.

Operating period Dec. 15, 1906, to Dec. 31, 1907.

Income.

Cash balance Dec. 31, 1906, . . .	$ 7,199.21		
Assessment Founders, ...	29,999.97		
Assessment Associates (offices), . . .	9,408.55		
Assessment miscellaneous (meetings), .	4,041.75		
Telephone and operating, ...	1,997.65		
			$52,647.11

Expenditures.

Operating account, ...	28,896.96		
Stationery and printing, ...	1,890.26		
Insurance, ...	2,339.19		
Total operating expenses, . .		$33,126.41	
Building equipment (construction account),		10,039.85	
Furniture and fixtures, ...		1,307.41	
Depreciation and reserve fund, . . .		5,000.00	
Balance (surplus on hand), . . .		3,173.44	
			$52,647.11

MEMBERSHIP.

[T]he following list comprises the names of those persons [ele]cted as members or associates, who accepted election dur[ing] January and February, 1908:

MEMBERS.

[Char]les W. Abbott,	Pioche, Nev.
[Will]iam Aplin,	Cumberland, N. Queensland, Aus.
[Albe]rt H. B. Arnold,	Joplin, Mo.
[Rich]ard F. Bohler,	New York, N. Y.
[Will]iam L. Borthwick,	Tenabo, Nev.
[Rob]ert A. Bryce	Cobalt, Ontario, Can.
[Fre]d T. Buell,	Copperhill, Tenn.
[Law]rence N. B. Bullock,	Copala, Sinaloa, Mex.
[Erne]st B. Caldwell,	Santa Lucia, Sinaloa, Mex.
C. Christy,	Phoenix, Ariz.
[Sam]uel C. Faneuf,	Rosario, Sinaloa, Mex.
[Char]les Fowles,	Boston, Mass.
[Wal]ter A. Fulton,	Guanajuato, Mex.
C. Gibson,	Penon Blanco, Durango, Mex.
Gorow,	Taxco, Guerrero, Mex.
[Jose]ph J. Greit,	New York, N. Y.
[Robe]rt W. Hadden,	Albuquerque, N. Mex.
[Dan]iel F. Hewett,	Pittsburg, Pa.
[Walt]er A. Holbrook,	Hedley, B. C., Can.
[Flet]cher R. Hunt,	Iron Mountain, Cal.
i Kaishima,	St. Augustine, Fla.
[Way]ne G. Klugh,	Toledo, O.
[Lew]is Lawrence,	Yuma, Ariz.
s A. Lewisohn,	New York, N. Y.
k A. Linforth,	Butte, Mont.
[Fred]erick F. McIntosh,	Sewickley, Pa.
W. McKim,	Salt Lake City, Utah.
[Alex]ander C. S. McLeod,	Daylesford, Victoria, Aus.
C. McMaster,	Toronto, Can.
[Albe]rt L. Martin, Jr.,	Pittsburg, Pa.
[Elw]ood V. Matlack,	St. Louis, Mo.
[Will]iam G. Norrie,	Coleman, Alberta, Can.
[Fran]cis R. Pyne,	Great Falls, Mont.
. Srinivas Rao,	Bombay, India.
in C. Reeder,	Copper Cliff, Ontario, Can.
[Alex]ander S. Reid,	London, England.
J. Reynoso,	Mexico City, Mex.
y C. Schmidt,	Matehuala, San Luis Potosi, Mex.
[Geor]ge B. Upton,	Wickenburg, Ariz.

Alois Weiskopf, ... Hanover-Linden, Germany.
William G. Whildin, ... Lansford, Pa.
Job H. Winwood, ... Salt Lake City, Utah.
Edwin F. Yates, ... Rawhide, Nev.

Associate.

John F. Thomas, ... Sharon, Pa.

CANDIDATES FOR MEMBERSHIP.

MEMBERS.

es Stuart Anderson, ... Kabulayatkatti, India.
ry John Arkell, ... Bluefields, Nicaragua, Central America.
liam Herbert Bainbridge, ... Searchlight, Nev.
ry Pickands Banks, ... Great Falls, Mont.
athan Bartley, ... Jersey City, N. J.
rles Peter Berkey, ... New York, N. Y.
id E. Blake, ... Bridgewater, N. S., Can.
dolph Bolling, ... Sydney, N. S., Can.
Brewer, ... New Haven, Conn.
rge Sage Brooks, ... De Pue, Ill.
liam Nelson Brown, ... Ocotlan, Oaxaca, Mex.
Gordon Chaney, Jr., ... Baltimore, Md.
liam Bullock Clark, ... Baltimore, Md.
liam Elmer Crawford, ... Chinipas, Chihuahua, Mex.
uel Herrera de Hora, ... Butte, Mont.
ustus W. Drake, ... Lattimer Mines, Pa.
se Stewart Duffield, ... Salt Lake City, Utah.
vell Fisher, ... Everett, Mass.
hur C. Fox, ... Virginia, Minn.
ter Taylor Frizzell, ... Chinipas, Chihuahua, Mex.
liam Harris, ... Seattle, Wash.
ry Stewart Harrop, ... Pittsburg, Pa.
bert Baring Horwood, ... Johannesburg, Transvaal, S. Africa.
hur J. Hoskin, ... Golden, Colo.
is Albert Jeffs, ... Salt Lake City, Utah.
ton Jenkins, Jr., ... Columbia, Pa.
tin Hamilton Kilgour, ... Golden, Colo.
old F. King, ... Kingston, N. Y.
hael Henry Kuryla, ... Santa Barbara, Chihuahua, Mex.
hur H. Lewis, ... Hazleton, Pa.
rles Rolfe McCollom, ... Minneapolis, Minn.
liam McMurtrie, ... New York, N. Y.
han Haines Mannakee . . . . Williamson, W. Va.
Maschmeyer, ... Antwerp, Belgium.
is A. Parsons, ... New Haven, Conn.
ene Roche Rice, ... Wickenburg, Ariz.
as E. Scott, ... Fairmont, W. Va.
ry Gilham Smith, ... Concheno, Chihuahua, Mex.
vard Ira Smith, ... State College, Pa.
n Gordon Smyth, ... Fairmont, W. Va.
nt Thomas Stephenson, ... Wells, Mich.
ry Bowman Taylor, ... Kansas City, Mo.
mas Martin Topp, ... Richmond, Cal.
haniel Parker Turner, ... Santiago, Cuba.
es S. C. Wells, ... New York, N. Y.

ASSOCIATES.

John H. Eggers, Jr., ... Alameda, Cal.
Hugh Vivian, ... Freiberg, Saxony, Germany.

CHANGE OF STATUS.

Lee E. Ives, ... Minneapolis, Minn.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address ol members have been re-
ved at the Secretary's office during the period of Jan. 1 to
r. 1, 1908. This list, therefore, supplements the annual list
members corrected to Jan. 1, 1908, and brings it up to the
e of Mar. 1, 1908. The names of Members who have ac-
ted election during January and February, 1908 (new mem-
s), are printed in *italics*.

By a simple method of cutting out these names and addresses,
l pasting them directly over the corresponding names in the
iual list of members, the record can be kept practically up
date and the value of the list correspondingly increased.
r this purpose the changes of address have been printed only
one side of the page. The names of new members, being
italics, are readily distinguished from the others, and can be
ted in approximate alphabetical order on the margins of the
ges of the list.

RONS, J. BOYD, Care L. Aarons & Co., 21 Grechem House, Old Broad St., London, E. C., England.
DIE, EMILE R. .... 516–519 Pacific Bldg., San Francisco, Cal.
bott, Charles W., Min. Engr. .... Pioche, Nev. '08
AMS, MASON T. .... P. O. Box 1238, Vancouver, B. C., Canada.
LECK, WILLIAM .... 307 Herald Square Hotel, New York, N. Y.
LAN, THOMAS A., Care Fergus Allan, Mexico Mines of El Oro, Apartado 17, El Oro, Mex., Mexico.
LEN, ROBERT, Care Veta Colorada Mining & Smelting Co., Villa Escobedo, Chih., Mexico.
lin, William, Met. and Assayer, Cumberland, No. Queensland, Australia. '08
nold, Albert H. B., Min. Engr. .... 307 Miners Bank Bldg., Joplin, Mo. '08
IOLD, CHARLES E. LEN .... Bisbee, Ariz.
KINSON, W. J. .... 171 Canora Street, Winnipeg, Manitoba, Canada.
ERY, COLBY M. .... Aurora, Ill.
BITT, THOMAS D. .... Emmett, Idaho.
G, RUFUS M., JR. .... University of Illinois, P. O. Box 125, Urbana, Ill.
DWIN, WILLIAM S. .... 170 South Broadway, Nyack, N. Y.
RDWELL, ALONZO F., Min. Engr., Mgr., Bettles, Mathez & Co., Assay Office & Chem. Laboratory, 158 S. W. Temple St., Salt Lake City, Utah.
RTOCCINI, ASTOLFO .... 230 E. 90th Street, New York, N. Y.
ES, MOWRY .... 30 State Street, Salt Lake City, Utah.

L, FRANK R. ....Bartlesville, Okla.
L, JOHN W., Asst. Prof. of Mining, Mining Dept., McGill University,
Montreal, Canada.
RAY, NILES S...................Care Old Dominion Commercial Co., Globe, Ariz.
CKBURN, HARRY H...........................2021½ First Ave., Birmingham, Ala.
W, A. A...37 Wall Street, New York, N. Y.
ler, Richard F., Met Engr., Kaffenberg Steel Works, Kaffenberg,
Syria, Austria. '08
ROW, FRANK K., Care Hyde, Tandy, Mahon & Sayer, 33 Ely Place,
Holborn, London, E. C., England.
thwick, William L., Min. Engr., U. S. Deputy Mineral Surveyor,
Tenabo, Nev. '07
IE, ALEXANDER..Bowie, Colo.
D, WILLIAM S., Care Boston Consolidated Mining Co., P. O. Box 1388,
Salt Lake City, Utah.
NTON, ARTHUR J., Supt. Blast Furnaces, National Tube Co.,
230 Third Street, Elyria, Ohio.
DEN, WILLIAM...71 Broadway, New York, N. Y.
DFORD, ROBERT H......................University of Utah, Salt Lake City, Utah.
DLEY, D. H., JR...........................Apartado 155, Parral, Chih., Mexico.
CHI, VICTOR M., Engr. and Contractor, Calle de Cadena No. 2,
Apartado 830, Mexico City, Mexico.
WN, ARTHUR H...........................133 Kent Street, London, Ont., Canada.
WN, HARVEY S..... ....802 Lander St., Reno, Nev.
ce, Robert A., Mine Supt., Cobalt Silver Queen Mine,
Cobalt, Ont., Canada. '07
ROW, LESTER R.......................................Angangueo, Michoacan, Mexico.
ll, Lloyd T., Min. Engr..........Tennessee Copper Co., Copperhill, Tenn. '07
lock, Laurence N. B., Met...Care Chas. Butters, Copala, Sinaloa, Mexico. '07
MAN, JOHN...................Trentham, Stoke-on-Trent, Staffordshire, England.
lwell, Forest B., Min. Engr.....................Santa Lucia, Sinaloa, Mexico. '07
ERO, JOSÉ, Min. Engr., Mgr. of the "Sta. Gertrudis y Guadalupe"
M. C. Cia Minera de Sta. Gertrudis y Guadalupe, Pachuca, Hidalgo, Mexico.
PBELL, FRANK J..603 Symes Bldg., Denver, Colo.
LMERS, WILLIAM J..................................7733-15 Adams St., Chicago, Ill.
SE, CHARLES A.....................................921 Equitable Bldg., Denver, Colo.
BAS, EDUARDO J.........................Marina Alta 4, Santiago de Cuba, Cuba.
HOLM, JOHN........................... ....Instructed to hold all mail.
isty, Fred C., Min. Engr...Phœnix, Ariz. '07
RCH, JOHN L...P. O. Box 200, Goldfield, Nev.
S, DAVID, Asst. Genl. Mgr., Cananea Consolidated Copper Co.,
Cananea, Sonora, Mexico.
E, FRANK L., Min. Engr..Tientsin, China.
LINS, EDGAR A.............Supt. Montana-Tonopah Mining Co., Tonopah, Nev.
LORD, GEORGE L..........................Shenango Furnace Co., Sharpsville, Pa.
BRO, JOHN P......................................Federal Lead Co., Flat River, Mo.
ION, GEORGE G......Black Mountain Mining Co., Magdalena, Sonora, Mexico.
LINGTON, WAYNE..Boise, Idaho.
T, ALBERT C., Min. Engr. and Geol., School of Mines,
University of Wyoming, Laramie, Wyo.
RMOND, CHARLES F., Min. Engr., Mgr., Ruby Mountain Mining Co., Joy, Nev.
KSON, ARCHIBALD A. C., Cons. Min. Engr., Rejoulie P. O. via
Nawadah E. I. Ry., Gaya District, Lower Bengal, India.

GWALL, WILLIAM B. A., P. O. Box 113, Matehuala, San Luis Potosi, Mexico.
INIAN, LEON....................Apartado 3021, Mexico City, Mexico.
IER, CHARLES T....................Redding, Cal.
PER, FRED. C....................Lebanon, Mo.
M, FRANK G., 704 West Coast Life Bldg., Pine and Leidesdorff Sts., San Francisco, Cal.
FAUR, JOHN B., Electrolytic Smelting & Refining Co. of Australia, Woollomgong, N. S. W., Australia.
RFEE, ELMER W., Genl. Supt....................Daly Judge Mine, Park City, Utah.
TON, WILLIAM F....................74 W. 68th Street, New York, N. Y.
VARDS, VICTOR C., Vice-Prest......Morgan Construction Co., Worcester, Mass.
AM, ALBERT S., Cons. Min. Engr., Camomile St. Chambers, Bishopsgate St. Within, London, E. C., England.
IS, EDWIN E....................202 Wolvin Bldg., Duluth, Minn.
SWORTH, LINCOLN, Instrumentman, Construction Dept., Canadian Pacific Railway, Montreal, Canada.
IONS, N. H., 2ND, Asst. Mgr....................Tennessee Copper Co., Copperhill, Tenn.
NG, FREDERIC....................Care The Vetera Mine, Kimberly, Nev.
neuf, Samuel C., Min. Engr....................Rosario, Sinaloa, Mexico. '07
GIE, CHARLES....................P. O. Box 64, Sydney, Cape Breton, N. S., Canada.
LD, FREDERICK M....................Montgomery-Shoshone Mines Co., Rhyolite, Nev.
LDING, CHARLES W....................Belmont, Faversham, Kent, England.
ER, WALTER G....................P. O. Box 1465, Salt Lake City, Utah.
K, WILLIAM N....................P. O. Box 484, Tonopah, Nev.
SYTH, ALEXANDER....................1033 Wheeler Ave., Reno, Nev.
TER, FLOYD J....................Galeana No. 6, Monterey, N. L., Mexico.
TER, LEWIS E....................Utah Copper Co., Garfield, Utah.
des, Charles, Mine Mgr....................6 Beacon St., Boston, Mass. '07
SER, ALEXANDER J....................Old Glory, via Tucson, Ariz.
ZIER, WILLIAM T....................317 Hicky Street, Santa Ana, Cal.
CHEVILLE, WILLIAM....................High Wykehurst, Ewhurst, Guildford, England.
EMAN, AMBROSE W., Challis House, Martin Place, Sydney, N. S. W., Australia.
CK, HENRY C....................Room 1924 Frick Bldg., Pittsburg, Pa.
lton, Chester A., Min. Engr....................Apartado 78, Guanajuato, Mexico. '07
TRELL, HERBERT W....................Gawler, So. Australia.
VIN, C. J....................1761 Washington Ave., Denver, Colo.
SENDORFER, HENRY A., Supt., Copper Creek Development Co., Hillside, Ariz.
MELL, ROBERT C., Genl. Supt., Utah Copper Co., McCornick Block, Salt Lake City, Utah.
PERT, RICHARD M....................P. O. Box 144, Goldfield, Nev.
B, ALLAN, Care Robert Williams & Co., 30 and 31 Clements Lane, Lombard St., London, E. C., England.
AULT, EDMUNDO....................3a Calle Prim No. 56, Mexico City, Mexico.
DMAN, MARCUS I....................U. S. Geological Survey, Washington, D. C,
ow, Boris, Mine Mgr....................Taxco, Guerrero, Mexico. '07
ENE, FRED. T....................Stanford, Montana.
gson, William H., Care The Conigas Mines, Ltd., Cobalt, Ontario, Canada. '02
it, Adolph J., Min. Engr....................27 William Street, New York, N. Y.
FFITHS, CHARLES G....................15 William St., New York, N. Y.
dden, Robert W., Cons. Min. Engr....................Albuquerque, New Mexico. '07
GOTT, EDWARD A....................2525 Powell St., San Francisco, Cal.
GOTT, ERNEST A....................510 I. W. Hellman Bldg., Los Angeles, Cal.

L, BENJAMIN M., Cons. Engr....................413 Temple Court, Atlanta, Ga.
ILTON, CHARLES A....................................Apartado 42, Oaxaca, Mexico.
COCK, H. LIPSON, Mine Mgr., Walaroo & Moonta Mining &
Smelting Co., Walaroo, So. Australia.
DMAN, JOHN E., Cons. Min. Engr., Room 64, 112 St. James St.,
Montreal, Canada.
DY, J. GORDON, Min. Engr.......Altura Park, 204 Texas St., El Paso, Texas.
rris, Edwin F., Mine Owner and Mgr., Colorado Mining Co., Box 1035,
Tucson, Ariz. '07
RIS, HENRY...............Tasmania Mining & Smelting Co., Zeehan, Tasmania.
KELL, J. A...............................Room 1609, 140 Cedar St., New York, N. Y.
RNE, D. GARTH....................................City Bank Bldg., Wheeling, W. Va.
BARD, AUSTIN, Block B, Langlaagte Estate & Gold Mining Co., Ltd.,
P. O. Box 58, Langlaagte, Transvaal, So. Africa.
LER, MARTIN J.............................43 Exchange Place, New York, N. Y.
RY, JOHN L...1114 Seventh Ave., Oakland, Cal.
oett, Donald F., Min. Engr....................325 Water St., Pittsburg, Pa. '08
WOOD, WILLIAM A., Concordia, Little Namaqualand, Cape Colony, So. Africa.
ON, HIRAM W...............................Normandie Hotel, Philadelphia, Pa.
BERTON, WALTER T., Compania Estanifera de Llallagua Bolivia,
Llallagua, via Antofagasta, Chile, So. America.
lbrook, Elmer A., Mill Supt., Daly Reduction Co., Ltd.,
Hedley, B. C., Canada. '08
IE, DOUGLAS R...Survey Dept., Giza, Cairo, Egypt.
BARD, HARRY J., Minas Bonanza y Anexas, Bonanza,
Zacatecas, via Saltillo, Mexico.
nt, Thatcher R., Engr., Mt. Coffer Co., Iron Mountain, via Keswick, Cal. '08
TER, HANSABURO.......................1 St. Mary Axe, London, E. C., England.
INETTE, VICTOR..................North American Lead Co., Fredericktown, Mo.
, LEE E.......................................222 W. 25th Street, Minneapolis, Minn.
KINS, CHARLES V...................................2319 Ward Street, Berkeley, Cal.
KS, THOMAS H., Ferrocarril de Cananea, Rio Yaqui y Pacifico,
San Blas, Distrito de Fuerte, Sinaloa, Mexico.
NINGS, E. P.......................................P. O. Box 841, Salt Lake City, Utah.
NSON, ALEXANDER T...Care Jim Butler Tonopah Mining Co., Tonopah, Nev.
NSON, FRED L.............................325 E. Anopamn St., Santa Barbara, Cal.
NSON, ROBERT R..................47 Glenmore Road, London, N. W., England.
ES, THOMAS D., Vice Prest. and Genl. Mgr., Mill Creek Coal Co.,
Hazleton, Pa.
IHN, CARL E.................(Formerly Carl E. Juhlin), Benton, Mono Co., Cal.
ishima, Kenji, Min. Engr., Care Mrs. Regero, Marion Street,
St. Augustine, Fla. '08
NEDY, EUGENE P........Alaska Treadwell G. M. Co., Treadwell City, Alaska.
DIE, THOMAS............Northport Smelting & Refining Co., Northport, Wash.
SAM, WILLIAM A............Hotel Earlington, 55 W. 27th St., New York, N. Y.
ugh, Bethune G., Chem.....................Care Toledo Furnace Co., Toledo, Ohio.
EHLER, WILLIAM..............East 4706 Superior Ave., N. E., Cleveland, Ohio.
ABLER, EMIL..................Bertholdstrasse 18, Essen, Ruttenschied, Germany.
UMB, HENRY, Min. Engr......420–21 McCornick Bldg., Salt Lake City, Utah.
UTTSCHNITT, JULIUS, JR.............................P. O. Box 229, Morenci, Ariz.
NDERS, WILLIAM H.......................160 Sansome Street, San Francisco, Cal.
NE, HENRY M...............................1924 Prospect Ave., Cleveland, Ohio.

rence, Willis, Supt..........................Picacho Basin Mines, Yuma, Ariz. '08
E, NEVILLE, Mazapil Copper Co., Ltd., Concepcion del Oro,
Zacatecas, Mexico.
ND, FRANK M..French Gulch, Shasta Co., Cal.
LE, E. FLEMING ....240 W. 104th Street, New York, N. Y.
LE, EDWARD M............................240 W. 104th Street, New York, N. Y.
NGS, GLENN V. B...................Apartado 5, Santa Barbara, Chih., Mexico.
s, ROBERT S.......................Cumberland Ely Copper Co., Kimberly, Nev.
sohn, Julius A., Min. Engr................42 Broadway, New York, N. Y. '08
BERG, CAROL O., Genl. Supt. of Mines and Mill, The Benito Juarez
Mines Co., Sanilas, S. L. P., Mexico.
SAY, LYCURGUS.............................720 South Olive St., Los Angeles, Cal.
orth, Frank A., Asst. Geol., Amalgamated Copper Mining Co.,
626 Hennesy Bldg., Butte, Mont. '08
RMORE, THOMAS L., JR., Mine Mgr..................................Telluride, Colo.
AN, FREDERICK W.........................700 Oneida Block, Minneapolis, Minn.
AN, ROBERT H., Compania de Real del Monte y Pachuca,
Pachuca, Hidalgo, Mexico.
SKELL, JASPER A....Care McCornick Bros., 71 Broadway, New York, N. Y.
ELLAND, JAMES F.................................P. O. Box 1066, Palo Alto, Cal.
RMICK, EDWARD.................................1564 Hecla Street, Calumet, Mich,
ntosh, Frederick F., Teacher of Met...............................Sewickley, Pa. '08
ECHNIE, BENJAMIN E...............................847 Maple Street, Lebanon, Pa.
Kim, John W., Min. Engr......326-7 Dooly Block, Salt Lake City, Utah. '07
eod, Alexander C. S., Battery Manager...Daylesford, Victoria, Australia. '07
Master, Alexander T. C., Min. Engr., 742 Spadina Avenue,
Toronto, Ont., Canada. '08
DONALD, JESSE J..........Care El Tigre Mining Co., Yzabal, Sonora, Mexico.
TIN, DR. A. A..........................Handelstr. 6, Berlin, N. W. 23, Germany.
tin, Robert L., Asst. Genl. Mgr., Bessemer Coke Co.,
714 Lewis Block, Pittsburg, Pa. '08
HAM, CHARLES A...........................1727 Hamilton Street, Allentown, Pa.
lack, Ellwood V., Prest., The Laclede Power Co. of St. Louis,
420 Olive St., St. Louis, Mo. '08
ERN, HERMAN...Hornbrook, Cal.
RIAM, WALLACE W..Chihuahua, Mexico.
RILL, CHARLES W..........................2000 Santa Clara Ave., Alameda, Cal.
ER, JESSE W..........Rosario Mining & Milling Co., Urique, Chih., Mexico.
ER, JOSEPH.........................Mt. Paris Tin Mine, Ringarooma, Tasmania.
ER, WILLIAM P., JR...........................1027 Page St., San Francisco, Cal.
s, LOUIS D.........."The Angelus," Jones and Bush Sts., San Francisco, Cal.
HELL, GEORGE.......................... ....1367 So. Figueroa St., Los Angeles, Cal.
HELL, PENTECOST, Genl. Mgr., Oliver Iron Mining Co.,
605 Wolvin Bldg., Duluth, Minn.
EY, FREDERICK H..........................412 McPhee Building, Denver, Colo.
RIS, FRED. L., Min. Engr.........1028 Monadnock Bldg., San Francisco, Cal.
RIS, HENRY C............. ....118 Sierra St., Reno, Nev.
E, WILLARD S......................700 McCornick Block, Salt Lake City, Utah.
E, GEORGE F..Needles, Cal.
HY, THOMAS D., Ventanas Mining & Exploration Co., Ltd.,
Ventanas, via Chavarria, Durango, Mexico.
RAVE, EDWARD C., Care Deer Lodge Cons. Mines.........Deer Lodge, Mont.

MUSSEN, HORACE W..Collingwood, Ont., Canada.
NICHOLLS, JOHN C., Min. Engr., Supt., Oriental Cons. Mining Co., Unsan, Korea.
**Norrie, William G.*, Asst. Engr., International Coal & Coke Co.,
Coleman, Alberta, Canada. '08
NOYES, WILLIAM S.................................819 Mills Bldg., San Francisco, Cal.
OF, CHARLES...892 Prospect Ave., New York, N. Y.
OVERPECK, A. C., Supt., Continental Copper M. & S. Co.,
Dakota Calumet Camp, Hill City, So. Dak.
OXNAM, THOMAS H., Cons. Min. Engr........231 R. F. D. No. 5, Los Angeles, Cal.
PALMER, WILLIAM J. A....................................San Marcos, Sinaloa, Mexico.
PARK, MUNGO...............Glan Ceris, Merai Bridge, North Wales, Great Britain.
PARSONS, WILLIAM B.................................60 Wall Street, New York, N. Y.
PASSOW, FREDERICK M..............Ivanpah Consolidated Mining Co., Nipton, Cal.
PATTBERG, OTTO F...Coal City, Ala.
PAYNE, HERBERT C...............Stettin Lodge, Dulwich, London, S. E., England.
PECHIN, JOHN S...Greyledge Farm, Buchanan, Va.
PERKS, HARRY B.........Care Whiting & Runton, 82½ Third Street, Portland, Ore.
PETERS, RICHARD, JR., Purchasing Agent, Birmingham Coal & Iron Co.,
Brown-Marx Bldg, Birmingham, Ala.
PETERSON, ROSCOE L., Prest., The Conveying Weigher Co.,
90 West St., New York, N. Y.
POTTER, EDWARD C.................................4741 Greenwood Ave., Chicago, Ill.
POWEL, GODWIN H..................Isthmian Club, Piccadilly, W., London, England.
PULSIFER, HARRIE B..................................817 Oak Street, Kansas City, Mo.
**Pyne, Francis R.*, Met. Chem., Boston & Montana Smelter,
Great Falls, Mont. '08
QUENEAU, A. L. J...............................Bartlesville Zinc Co., Bartlesville, Okla.
RALSTON, WILLIAM C...............................353 Bush Street, San Francisco, Cal.
**Rao, M. N. Srinivas*, Geol.........Care Tata Sons & Co., Fort, Bombay, India. '07
REDFEARN, ALBERT M..... ....Lake Geneva, Wis.
REECE, FREDK. B..."The Smead," Lead, So. Dak.
**Reeder, Edwin C.*, Asst. Supt., Canadian Copper Co.,
Copper Cliff, Ont., Canada. '08
REESE, JOHN N..Ivanhoe, Wythe Co., Va.
**Reid, Alexander S.*, Min. Engr., Care Waihi Gold Mining Co., Ltd.,
11 Abchurch Lane, London, E. C., England. '07
REIDT, CARLOS..Instructed to hold all mail.
REQUA, MARK L., Min. Engr...........1023–26 Crocker Bldg., San Francisco, Cal.
**Reynoso, José J.*, Min. Engr., Coliseo Nuevo 440, Apartado 768,
Mexico City, Mexico. '08
RHODES, CLARENCE E., Supt., San Prospero Mine and Mill,
Mexican Milling & Transportation Co., Apartado 25, Guanajuato, Mexico.
RICE, GEORGE SAMUEL.................1417 First National Bank Bldg., Chicago, Ill.
RICHARDSON, DAVIS.......................Room 2012, 5 Nassau St., New York, N. Y.
ROBERTS, J. C...Technologic Branch, U. S. Geological Survey, Washington, D. C.
ROBESON, JACOB H..218 Boston Bldg., Denver, Colo.
ROGERS, ALEXANDER P..52 Broadway, New York, N. Y.
ROSE, HUGH...71 Broadway, New York, N. Y.
ROSENFELD, LOUIS.....................1024 Merchants Exchange, San Francisco, Cal.
ROSS, LEWIS P., Mgr..............................Northern Iron Co., Standish, N. Y.
SALSICH, LE ROY...Taconite, Minn.
SANDERS, JOHN, Chem...................Southern Arizona Smelting Co., Sasco, Ariz.

SANDERS, R. H..617 Drexel Bldg., Philadelphia, Pa.
SCHEFFLER, F. G.................................64 Luisen Str., Berlin, N. W. 6, Germany.
*Schmidt, Henry C., Mine Supt...........Matehuala, San Luis Potosi, Mexico. '08
SCHORR, ROBERT.....................................61 Fremont Street, San Francisco, Cal.
SCHWERIN, CLARENCE M...............................35 De Hart Place, Elizabeth, N. J.
SCOTT, WINFIELD G...539 W. 8th St., Long Beach, Cal.
SELKIRK, WILLIAM, Cons. Min. Engr., 62 London Wall, London, E. C., England.
SHAW, HOWARD I..P. O. Box 1000, Helena, Mont.
SHAW, RICHARD C..Summerville, S. C.
SHERMAN, SCOTT H..Christmas, Ariz.
SHOWERS, CHARLES H......................................P. O. Box 123, Colima, Mexico.
SHURICK, ADAM T..................Washoe Copper Co., Washoe, Carbon Co., Mont.
SISTERMANS, FRANCIS H., Cons. Min. Engr., 5a Gabino Barreda No. 103,
Mexico City, Mexico.
SLOAN, W. ARTHUR, Chief Chem............... ..Shannon Copper Co., Clifton, Ariz.
SMITH, E. PERCY.....................................655 St. Mark's Ave., Brooklyn, N. Y.
SMITH, EDWARD A......The Mexico Mines of El Oro, Ltd., El Oro, Mex., Mexico.
SMITH, GEORGE OTIS.........Director, U. S. Geological Survey, Washington, D. C.
SMITH, WILLIAM ALLEN, United Zinc & Chemical Co.,
318 Dwight Bldg., Kansas City, Mo.
SPANGLER, HOWARD..Goldyke, via Mina, Nev.
STAFFORD, C. EDWARD.................................Tidewater Steel Co., Chester, Pa.
STARK, HERBERT S.......... ....80 Wall Street, New York, N. Y.
STARKEY, TOM R...................Penmaen, Hampton Wick, Middlesex, England.
STEPHENS, FRANCIS B...Instructed to hold all mail.
STEWART, JOHN B.....................................Apartado 34, El Oro, Mex., Mexico.
STILES, THOMAS W......University Club, 5th Ave. and 54th St., New York, N. Y.
STOCKDALE, ARTHUR H., 60 Calle de Gabino Barreda No. 118,
Mexico City, Mexico.
STOIBER, MRS. EDWARD G. (formerly Lena Allen Stoiber),
1022 Humboldt St., Denver, Colo.
TALCOTT, MORRIS G...Morenci, Ariz.
TAYLOR, FREDERICK W..................Apartado 43, Matehuala, S. L. P., Mexico.
†Thomas, John F., Asst. Field Engr., Carnegie Steel Co., 15 Logan Ave.,
Sharon, Pa. '08
THOMAS, MARION L...Manzanillo, Colima, Mexico.
THORN, JOSEPH F., Supt.............................The Buster Mine, Elk City, Idaho.
THORNTON, EDWARD T., Supt., Minas Delores y Anexas, Apartado 30,
Matehuala, S. L. P., Mexico.
THROPP, JOSEPH E., Genl. Mgr...........Blast Furnaces, Mines, etc., Earlston, Pa.
TONKIN, JOHN...Hermon, N. Y.
TOUZEAU, E. M..... ..19 St. Helen's Place, Bishopsgate, London, E. C., England.
TOWNSEND, ARTHUR R..Telluride, Colo.
TURNER, HENRY W.........................Room 709, Mills Bldg., San Francisco, Cal.
UPHAM, W. E............... ......1, Mecklenburgh Square, London, W. C., England.
*Upton, George B., Min. Engr. and Mgr., Oro Grande Mine,
Wickenburg, Ariz. '08
VIGEON, EDWARD C., Genl. Mgr., Sociedad Minas de Cobre de Cutter Cove,
Punta Arenas, Chile, So. America.
VILLADSEN, ANDERS B............................Portland Cement Co., Portland, Colo.
VOGEL, FELIX A.............................Room 337, 25 Broad St., New York, N. Y.
Walcott, Charles D.........Secretary, Smithsonian Institution, Washington, D. C.

ALKER, EDWARD, Care *Mining and Scientific Press*, 808 Salisbury House, London, E. C., England.
ARD, WILLIAM F....2564 W. 32d Avenue, Denver, Colo.
ATTERS, DANIEL M., Anderson Map Co., Inc., 426 Epler Block, Seattle, Wash.
EIR, CHARLES G....893 Park Avenue, New York, N. Y.
Weiskopf, Dr. Alois, Met. Engr., Goetlinger-Chaussee 18, Hannover, Linden, Germany. '07
ELD, CHRISTOPHER M....2 Rector St., New York, N. Y.
ELLMAN, S. T....8803 Euclid Ave., Cleveland, Ohio.
ELLS, BULKELEY....Telluride, Colo.
EPFER, G. W....9 Masonic Bldg., Reno, Nev.
ETHEY, A. H....P. O. Box 308, Butte, Mont.
HEELOCK, RAYMOND P., "The Brunson," 347 So. Grand Ave., Los Angeles, Cal.
HERRY, HENRY P., Mexican Investment & Development Co., Mina Agua Blanco, Ayutla, Jalisco, Mexico.
Whildin, William G., Div. Supt., Lehigh Coal & Navigation Co., Lansford, Pa. '08
HITE, MARCUS....Idaho Hotel, Silver City, Idaho.
ICKES, L. WEBSTER....P. O. Box G, Pioche, Nev,
ILDING, JAMES, JR., Care Wilding & Keller, Apartado 134, Parral, Chih., Mexico.
ILES, EDWIN L....Stony Point, Rockland Co., N. Y.
ILEY, WALTER H....367 So. Bonnie Brae St., Los Angeles, Cal,
ILKENS, HENRY A. J....New Jersey Zinc Co., 71 Broadway, New York, N. Y.
ILKINS, WILLIAM, Mgr......Lake Superior Iron & Chem. Co., Ashland, Wis.
ILLIAMS, FRED. T....Daly West Mining Co., Park City, Utah.
ILLIAMS, JOHN R......P. O. Box 4375, Johannesburg, Transvaal, South Africa.
ILSON, GORDON....Benallen, Kirkintilloch, near Glasgow, Scotland.
ILSON, NATHANIEL, Cons. Mech. Engr., 2 East India Ave. Leadenhall St., London, E. C., England.
Winwood, Job H., Min. Engr.......Commercial Block, Salt Lake City, Utah. '07
ISEMAN, PHILIP....1107 Union Trust Bldg., Los Angeles, Cal.
ITTENOOM, CHARLES H.........Muralgarra Station, via Yalgoo, West Australia.
OLFF, MARK A., The Poderosa Mining Co., Care H. A. Bethell & Co., Antofagasta, Chile, South America.
OMBLE, LLOYD A...Care Stegman & Co., Barranquilla, Colombia, So. America.
RIGHT, LOUIS A., Min. Engr....42 Broadway, New York, N. Y.
UST, FRITZ....Ludwigsalle 47, Aachen, Germany.
YER, SAMUEL S....Harrison Bldg., Columbus, Ohio.
Yates, Edwin F., Min Engr....P. O. Box 25, Rawhide, Nev. '08
ERN, EDWARD N., Engr....Clarksburg, W. Va.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Barnardo, William S. E., . .	. Surbriton, Surrey, England.
Bassett, Thomas B., ...	. Cumpas, Sonora, Mexico.
Bell, Stanislaus C. N., . . .	. Brisbane, Queensland, Australia.
Bellam, Henry L., ...	. Reno, Nev.
Berry, J. F., ...	. East Rand, Transvaal, S. Africa.
Bishop, Roy N., ...	. Kennett, Cal.
Bordeaux, Albert F. J., . . .	. Mexico City, Mexico.
Bradley, Richard J. H., . . .	. 15 William St., New York, N. Y.
Bruce, Thomas C., ...	. Consolidated Bldgs., Johannesburg, S. Af.
Burhans, Harry H., ...	. Michigan College of Mines, Houghton, Mich.
Cleland, George A., ...	. Tonopah, Nev.
Dikeman, J. M., ...	. Rough and Ready, Cal.
Dougherty, Clarence E., . .	. 41 Wall St., New York, N. Y.
Ekberg, Benjamin P., . . .	. 199 Main St., Johannesburg, S. Af.
Fleming, William L., ...	. Springdale, Wash.
Francis, George G., ...	. 117 St. George's Square, London, W., England.
Graves, MacDowell, ...	. Villaldama, N. L., Mexico.
Jewett, Eliot C., ...	. 2918 Morgan St., St. Louis, Mo.
Jones, Edward H., ...	. Globe, Ariz.
Knapp, Edwin E., ...	. Tonopah, Nev.
Livingstone, Charles H., . .	. Selby, Cal.
Lukis, E. duB., ...	. Ica, Peru, S. America.
McCann, Ferdinand, ...	. Los Grados, Guerrero, Mexico.
Mueller, Henry C., ...	. General Delivery, San Francisco, Cal.
Palacios, Jose G., ...	. Monterey, N. L., Mexico.
Reisinger, Paul, ...	. Great Northern Ry. Co., Minot, N. D.
Reynolds, Llewellyn, . . .	. 22 Webb St., Hammond, Ind.
Roberts, Fred C., ...	. Crystal Falls, Mich.
Roesler, August, ...	. 74 Broadway, New York, N. Y.
Schraubstadter, R. T., . . .	. 3215 Hawthorne Blvd., St. Louis, Mo.
Seward, John, ...	. 131 Washington St., East Orange, N. J.
Sharp, W. Goodenough, . .	. Paramibo, Dutch Guiana, So. America.
Shaw, Clarence L., ...	. Ely, Nevada.
Thomas, George W., ...	. Exposed Treasure Mining Co., Mojave, Cal.
Thomas, James A., ...	. 115 New Montgomery St., San Francisco, Cal.
Vaux, Charles A., ...	. P. O. Box 80, East Rand, So. Africa.
Watson, Ralph W., ...	. 122 E. S. Temple St., Salt Lake City, Utah.
Williams, Fred, ...	. 7 Laurence Pountney Hill, London, England,
Young, Frederick E., . . .	. Howe Sound, via Vancouver, B. C., Canada.

NECROLOGY.

The deaths of the following members have been reported the Secretary's office during January and February, 1908:

te of ction.	Name.	Date of Decease.
5.	*Peter T. Austen,	December 30, 1907.
1.	**George Davey,	October 12, 1907.
2.	*Adolf Ekman,	March 14, 1907
5.	*Francis T. Freeland,	January 26, 1908.
0.	*James B. Gallagher,	January —, 1908.
9.	*T. R. Gue,	July —, 1907.
6.	*Tom Cobb King,	February 27, 1908.
5.	*Clermont Livingston,	October 20, 1907.
6.	*Hoyt S. McComb,	February 26, 1907.
3.	*John McConnell,	October 22, 1906.
3.	*Francis A. Roepper,	——— —, ——.
5.	*William Seaton, Jr.,	January 18, 1908.
1.	*Harry L. Shrom,	June 12, 1907.

* Member. ** Life Member.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Biographical Notices, January and February, 1908.

Bi-Monthly Bulletin, No. 20, March, 1908.

THE following paragraphs comprise such information as the [S]ecretary has been able to obtain concerning the members and [a]ssociates whose deaths have been reported. Further partic[u]lars or corrections of errors, and biographical data concerning [d]eceased members or associates not already noticed in this way, [a]re solicited.

Charles W. Benton was born at Kezar Falls, Maine, Nov. 12, [1]843. We have no accurate knowledge concerning the early [p]art of his career. In 1871 he engaged with the N. Y. Hon[d]uras Rosario Mining Co., at San Juancinto, Honduras, C. A., [a]nd later was employed at the Monserrat mine at Yuscaran, [a]nd at Santa Lucia, Honduras, with the Tenero Mining & [M]illing Co. of Pennsylvania. In 1897 he became a member of [th]e Institute. At the time he was stricken with his last sick[n]ess he was employed at the Paymaster mine at Tucson, Ariz. [H]e died at Fairmount, Denver, Colo., Sept. 9, 1907.

William R. Boggs, Jr.—The notice in the *Bulletin* for Jan[u]ary was incorrect in saying that the murder of Mr. Boggs [o]ccurred while he was employed as metallurgical manager by [M]r. W. B. A. Dingwall, at La Maroma, San Luis Potosí, Mex. [M]r. Dingwall writes that in March, 1907, Mr. Boggs left him, [to] return to his home at Winston, N. C., whence he subse[q]uently went to Durango, Mex., to take, with the Topia Min[in]g Co., a position which he occupied at the time of his death, [N]ov. 17, 1907. Mr. Dingwall says that, while in his service, [M]r. Boggs never had any trouble with the workmen, but was [es]teemed and liked by them, as by all who knew him; and [ad]ds, in justice to the State of San Luis Potosí, that the popu[la]tion, even in the mining-camps of that State, is orderly and [la]w-abiding, and that the authorities are vigilant and just. Our

brief statement of Mr. Boggs's death should not be construed as a reflection upon the general social conditions, either of San Luis Potosí, where it did not, or of Durango, where, as now appears, it did take place. The unanimous testimony of American mining engineers in Mexico recognizes the general respect for law and order which is evinced by the Mexican people, and enforced, whenever necessary, by the Mexican government. Such an outrage as the murder of Mr. Boggs by a mob of ignorant and misguided laborers might have occurred—has, indeed, occurred—in our own country, and should not be charged to the account of the fancied inferior civilization of our great sister Republic.—R. W. R.

Chauncey E. Butler was born in 1878. In 1896, after graduating from college, he began his career as a mining engineer and assayer at El Oro, Durango, Mex., becoming in the same year a member of the Institute. In 1900 he entered the employ of the United Verde Copper Co., at Jerome, Ariz. In 1903 he became superintendent of the Trinity County Gold Mining Co., at Diedrich, Cal., and in 1904 he connected himself with the Wickenburg Mining & Smelting Co., having his headquarters at Phœnix, Ariz. After finishing his contract with that company, he returned, in October, 1906, to his home in Denver, where he remained until his death, which occurred Jan. 26, 1907. Mr. Butler was well and favorably known in the Southwest, where his active life had been spent.

George Davey was born Nov. 1, 1862, at Camborne, Cornwall, England. He came of a mining family, his grandfather having been the owner of extensive mining properties in the West Cornwall district, and his father being a well-known Cornish mining operator. Following the hereditary tendency so often exhibited in Cornish families, he received a technical education at the Redruth and Camborne School of Mines, and spent several years after his graduation in practical training under various engineers and mine-officials. From 1883 to 1891 he was employed in the copper-smelting works of Vivian & Sons at Hafod, South Wales. From 1891 to 1896 he was metallurgical superintendent of the Michoacan Railway & Mining Co., Ltd., Mexico; from 1897 to 1901, superintendent

the Waitekauri gold-mines, New Zealand; and in 1903–4, erintendent of the Mount Boppy gold-mines, New South ales. After two years spent in private consulting practice at ndon, he went, in February, 1907, to Tijola, Spain, where he ected the construction of a smelting-plant. Having suc-sfully fulfilled this engagement, he was about to enter upon imilar undertaking at Valverde, Huelva, Spain, when his ive and useful career was cut short by a sudden death, Oct. 1907. Mr. Davey became a member of the Institute in 1891, l a life-member in 1893. He was also a member of the titution of Mining and Metallurgy, the North of England titute of Mining and Mechanical Engineers, the Institution Mining Engineers, and the Mining Association and Institute Cornwall, and a Fellow of the Chemical Society. His death, the comparatively early age of 45, while it came much too n for the full realization of all the achievements promised his ability and character, did not prevent him from making otable and honorable professional record.

Francis T. Freeland was born in Philadelphia, Aug. 7, 1859. was graduated from the University of Pennsylvania, in the rse of mechanical engineering, in 1879, after which he took ost-graduate course in mining engineering, which he com-ted in 1881, at the same time occupying the position of in-uctor in mathematics and mechanics. While at the univer-Mr. Freeland distinguished himself as a mathematician, covering several new principles. He was exceptionally ficient in the science of mathematics. On leaving the uni-sity, in 1881, he went to Leadville, Colo., where he entered employment of the Iron Silver Mining Co. as mining engi-r, and in the course of a few years became the general erintendent of all the mines of the company. He joined American Institute of Mining Engineers in 1885 and soon erward contributed an important technical paper on the lphide Deposits of South Iron Hill, Leadville (*Trans.*, xiv., l). To subsequent volumes of the *Transactions* he contrib-d papers on Fault Rules (vol. xxi., p. 491) and Mining ases (vol. xxv., p. 106). Early in the '90s, Mr. Freeland k charge of important mining properties at Aspen, Colo., l in 1894 he became the general manager of the Isabella

mine at Cripple Creek. He remained in charge of the properties at Aspen and divided his time between Aspen and Cripple Creek. In 1902 he was with the Frisco Consolidated Mining Co. at Gem, Idaho. In the later years of his life Mr. Freeland retired from active work and devoted himself chiefly to traveling. Recently he returned from a trip around the world. He died suddenly at Philadelphia, Pa., Jan. 28, 1908.

James B. Gallagher was born in Sacramento, Cal., Nov. 27, 1856. He was educated in the public schools and the State University of Nevada, and was also a graduate of Heald's Business College, of San Francisco.

His first work was in charge of the express business of Wells, Fargo at Elko, Nev. Afterwards he was engaged for a short time in business at Colfax, Wash., whence he went to Butte in 1884, taking up the study of assaying and chemistry, and serving the Parrot Silver & Copper Co. as assayer and chemist for about three years. For one term he was deputy sheriff of Silver Bow county, Montana. In 1896–'97 he was employed for a brief period by the Montana Ore-Purchasing Co., but in 1897 he entered the service of the Anaconda Copper Mining Co., as a mine-examiner. In 1903 he became superintendent of the sampling department of the Washoe Smelter, at Anaconda. In 1904 he removed to Butte as manager of the Colorado Smelting & Mining Co., and also took charge of the Washoe Copper Co.'s sampler at Butte. These positions he occupied at the time of his death, which occurred Jan. 5, 1908. Mr. Gallagher joined the Institute in 1905.

Hoyt Sherman McComb was born Sept. 14, 1878, at Columbus, Ohio. From 1898 to 1899 he was employed in various mining-districts in Ohio, West Virginia, Pennsylvania and Indiana, as chainman, rodman, transitman, machine-runner and motorman. In 1899 he entered the Ohio State University and graduated as a mining engineer in 1904, having worked one year as assistant engineer for the Federal Coal & Coke Co., Fairmount, W. Va., and as resident engineer for the New England Coal Co., at Santoy, Ohio. In the summer of 1904 he took the position of chief engineer for the New England Coal Co., and in 1905 he went to Los Esperanzas, Coahuila,

[M]exico, as chief engineer for the Mexican Coal & Coke Co. In [M]ay, 1906, he became superintendent of the Coahuila Coal [C]o., a sub-company of the Mexican Coal & Coke Co., at [R]ondo, Coahuila, Mexico, and this position he held until he [di]ed, Feb. 26, 1907. He joined this Institute in 1906.

John McConnell was born Jan. 10, 1862, at Glasgow, Scot[la]nd. From 1878 to 1883 he was a student, first at Anderson's [C]ollege, and afterwards for two years at the Mechanics' Insti[tu]te (College of Science and Arts). From 1883 to 1888 he [se]rved as apprentice and chemist with the Tharsis Sulphur & [C]opper Co. From 1888 to 1891 he was manager of the Cassel [G]old Extracting Co. in New Zealand. From this position he [w]ent to the Crown Mines in New Zealand, where he was mana[ge]r for three years. For the ensuing year he was metallurgist [an]d chemist for the Silverton Gold Mining Co., and, for the [ye]ar 1896, of the Woodstock Gold Mining Co., both of New [Z]ealand. From 1899 to 1901 he served as mining engineer of [th]e Société Anonyme de Travaux Miniers in the Republic of [C]olombia, S. A., and for two years after he retired from this [po]sition, in 1901, he was general manager of the Tenuta [Et]ruscan Mines, Lanze Campiglia, Maritima, Italy. Subse[qu]ently he visited the Transvaal, but had retired from active [pr]actice and was living quietly in Glasgow when the end came, [Oc]t. 22, 1906. He was a member of the Institute of Mining [an]d Metallurgy, and became a member of this Institute in 1903.

Mr. McConnell's active and varied career brought him into [co]ntact with many branches of his profession, in all of which [he] won the confidence and esteem of employers and associates [ali]ke. He took an important part in perfecting and applying [th]e MacArthur-Forrest cyanide process, in connection with [wh]ich his ability was highly appreciated.

*Alfred Mayer Rock** was born Sept. 26, 1877, at Wash[in]gton, D. C. In June, 1900, he was graduated at Harvard [U]niversity, and, from July to September of the same year,

* The former notice of Mr. Rock, prepared from incomplete material and pub[lish]ed in *Bi-Monthly Bulletin*, No. 19, for January, 1908, contained serious errors [an]d omissions. The present sketch is printed as a substitute. For the new and [mo]re accurate details which it contains, I am indebted to Mr. F. L. Ransome.— [R.] W. R.

served at Rico and Silverton, Colo., as field assistant to Mr. F. L. Ransome, of the U. S. Geological Survey, returning in October to Cambridge, Mass., where he entered the Harvard graduate school. But in January, 1901, the death of his father in Guatemala obliged him to break off his course and go to that country, where he remained, managing a coffee-plantation, until the autumn of 1902, when he returned to the United States. From September, 1902, to January, 1903, he was again employed as assistant by Mr. Ransome—this time at Bisbee, Ariz. The valuable field-practice thus secured, however, did not satisfy him as a substitute for the more thorough theoretical study which he had originally contemplated, and he went for the third time to Harvard, where, in June, 1903, he took the degree of A.M., with Geology as his major subject. Resuming immediately his connection with the U. S. Geological Survey, he served from July, 1903, to February, 1904, as field-assistant to Messrs. Lindgren and Ransome at Cripple Creek, Colo., and Mr. J. M. Boutwell at Park City, Utah. At the latter date, he accepted the position of mine-surveyor of the Federal Lead Co., at Flat River, Mo., and, in the following April, was placed in charge of the diamond-drill prospecting-work of that company. During this year he became a member of the Institute.

In October, 1904, he was transferred to the New York office of the American Smelting & Refining Co., and was detailed to work in Mexico as principal assistant of Mr. J. E. Spurr, the company's geologist.

By his ability, industry and loyalty, Mr. Rock had won the esteem of his employers, and an assured prospect of rapid promotion to posts of higher responsibility, when his career was cut short, in his thirtieth year, by a heroic death. He was engaged, Aug. 7, 1907, in sampling the Santa Francisca mine, at Asientos, Aguascalientes, Mexico, when a fire broke out on the second level of the mine. The superintendent and the master mechanic of the mine, with other employees, obeying that high principle of "*noblesse oblige*" which, thank God! still holds good among miners, descended into the pit of danger to warn and rescue the men at work on the different levels, and to establish bulkheads for limiting and controlling the fire; and Mr. Rock (who, even according to that high code, was not, as a mere visitor, bound to assume such a risk) went with them as

volunteer, rightly deeming that his knowledge of the older vorkings would be of much assistance. They were successful n their generous purpose of saving the lives of others; but the uperintendent and the master mechanic, following the traitional miners' rule of honor that, in such cases, the officers dvance first and retreat last, lingered until they were overcome y the gases from the fire, and their volunteer companion shared oth their devoted courage and their fate. Another rescuearty brought the unconscious bodies of all three to the surface, here two of them were eventually restored to life; but Mr. lock was beyond resuscitation. He had not only risked but iven his life for his fellows.

"Greater love hath no man than this, that he lay down his fe for his friend," is one of the great utterances from lips livine which have inspired the world. But its deepest emphais is illustrated when another sublime saying from the same ps is combined with it, and a brave and kindly human soul, ot stopping to ask "Who then is my friend?" answers beforeand, "My fellow-man in trouble!"

It goes without saying that the lives sacrificed in such a spirit re likely to be the very ones which we could least afford to pare. Yet we may well reflect that one such sublime example nay inspire many followers, and that, however scantily supplied e may be with accomplished and trustworthy professional xperts, our stock of heroes is still smaller, and our need of nem greater. May it be long, indeed, before the miners and ne mining engineers shall cease to furnish them!

The story told above makes it almost unnecessary to add that Ir. Rock was an indefatigable worker, a thoroughly-equipped nd enthusiastic practitioner in his profession, brave, upright, enial, loving all men and beloved of all. It was a knight without fear and without stain," who thus gallantly rode to is early death!—R. W. R.

William Seaton, Jr., was born in 1873 at West New Brighton, taten Island, and after attendance at the local schools, and vo years spent on the school-ship *St. Mary's*, entered the office the C. W. Hunt Co. in the autumn of 1890, continuing his ngineering studies at the Cooper Union for some time thereter.

His ability as an engineer, particularly in the design of coal-handling plants, developed rapidly, and his importance with his company increased correspondingly, resulting in his election as Vice-President in 1906.

Among the more important installations which were, to a great extent, the results of Mr. Seaton's efforts, may be mentioned the coal-handling and storage plant of the Calumet & Hecla Mining Co. at Lake Linden, Mich.; the naval coaling-stations at Sangley Point, Philippine Islands; the Bremerton Navy-Yard, Seattle, Wash., and other points on the Pacific Coast; also the coal-mixing and storage plant of the Delaware & Hudson Railroad Co., situated at Delanson, N. Y.; and the freight-handling and reloading cranes of the Pennsylvania Railroad Co. at Greenville, N. J.

As an engineer, Mr. Seaton was broad-minded, his view comprehending the great essentials of a given problem, while at the same time he possessed the faculty of working out its details in an intelligent manner, and in applying machinery of a practical nature to accomplish the ends desired in a simple and economical manner.

Mr. Seaton was a man of striking appearance and charming personality. His manner was such as to secure at once the attention and confidence of those with whom he came in contact.

In addition to his membership in the Institute, which he joined in 1905, Mr. Seaton was also a member of the American Society of Civil Engineers and other technical organizations. He died Jan. 17, 1908, at Rosebank, Staten Island.

Henry Troth Townsend was born Oct. 1, 1851, at Philadelphia; graduated, 1870, as mechanical engineer at the Philadelphia Polytechnic College; became and remained for 10 years Treasurer of the Logan Iron & Steel Co. at Lancaster, Pa., of which he was then elected President. After 21 years of service in this capacity, making 31 years of continuous service with the company, he declined re-election on account of ill-health, but continued to be a director of that and several other important corporations, such as the Southwark Foundry & Machine Co. and the Philadelphia Board of Trade. He joined the Institute in 1879. His death, Sept. 1, 1907, after prolonged illness,

prived the community of an upright, successful and influen-
l citizen.

Jean Antony Variclé was born, 1853, in France. Dr. Variclé
s principally known through his interest in aëronautics—an
, to the development of which, in his native country, he made
luable contributions. In one of his adventurous aërial voy-
es he traveled with a companion from Paris over France and
lgium to the North sea, was carried back by a change of
nd over Holland, Westphalia and Hanover, and finally
ided near Hamburg, after a journey occupying 24 hours and
imated to cover 800 miles.

But the enterprise with which his name became identified
America, though it doubtless grew out of his connection
th ballooning, contemplated the discarding of the balloon
a means of polar explorations. Coming, in 1897, to Daw-
n, on the Klondike, in the British Yukon Territory, he en-
ged at first in gold-mining, and then practiced his profession
a physician, taking also a prominent part in public affairs,
d winning a secure position in the esteem of the community.
July, 1905, he organized the International Society for Polar
search and Experiment, with about 200 members, including
e Governor, several judges and other public officials, and the
mmandant of the Yukon division of that splendid body of
diers, the Northwest Mounted Police. The scheme of this
ciety was to make a dash into the unexplored North, after
e fashion of the scouting-parties of that corps—namely, by
expedition of picked men, equipped in light marching style,
th dogs and mules—the latter loaded with meat for the
mer, and destined to be ultimately themselves killed for the
ne use. The plan was to take two parties, of 20 men each,
m Seattle on a whaler, to the northern part of Grant Island,
out 1,000 miles northeast of the mouth of the Mackenzie.
e party was to establish a base of supplies 250 miles further
rth, and then return, while the second party was to make its
sh toward the pole from that base, even attempting to push
ross the polar continent and come out at Franz Joseph Land.
. Variclé had mastered all the practical details of such an
deavor, and explained them with contagious enthusiasm.
ppening to be in Dawson at that time, as one of the Insti-

tute party which visited the Yukon Territory after the British Columbia meeting, I talked the matter over with a veteran sergeant of the Northwest Police, who had made many such trips before. In fact, that corps has often executed long journeys through uncharted Arctic regions, of which no sensational reports have been published, though they might have been "written up" in a thrilling way, if only the corps were given to authorship or newspaper interviews. The sergeant told me gravely that the thing could probably be done. "Then why have your fellows never tried it?" I asked. "Because we have never received orders to that effect," he replied. "If you were ordered to go to the North Pole, could you do it in that way?" "We could undoubtedly go as far as there was any land," was the answer.

Dr. Variclé's generous hospitality to the members of the Institute party in Dawson culminated in the presentation, at a farewell banquet (at midnight, but in broad daylight), of a magnificent album of photographic views of the Yukon Territory, bound in caribou leather, richly embossed and ornamented with no small amount of gold-dust and nuggets from the Klondike diggings. He was subsequently elected by unanimous vote a Life Associate of the Institute.

For the purpose of arousing popular interest and securing support for his Polar enterprise, Dr. Variclé traveled much upon the Pacific Coast, lecturing on the subject. In 1906, he took up his residence in Seattle, which he intended to make the starting-point; but he was forced, partly by ill-health, to postpone (though he would never confess that he had abandoned) the great venture; and at last, after several months' suffering from a mortal disease, he died in that city, July 26, 1907.

Besides the enterprise with which his name was chiefly associated in this country, Dr. Variclé had distinguished himself as a versatile scientific investigator and inventor. While residing in the Yukon Territory, he made careful observations upon which he based an authoritative and universally accepted determination of the extremes of climatic temperature. Long before that, he is reported to have perfected a system for the telegraphic transmission of handwriting and drawings, and to have devised the famous "combination" key, with adjustable appliances, used by the French government in connection with

"time-locks," for the protection of post-office property. Rumor associates his name also with the origination of numerous small but ingenious and useful mechanical devices, concerning which, unfortunately, I have no accurate and adequate record. Indeed, it is difficult to do justice to his career upon the basis of a limited acquaintance with its last period only, and nothing but scattered hints of the years that went before. No doubt, if I knew more, I could tell something of his skill as a physician and surgeon—a department in which such ingenuity, acuteness, brilliancy of conception and boldness of execution as he evinced must have made their mark. This notice signalizes not his vocation, but his avocation, and is therefore incomplete to that extent—though, after all, what a man chooses and likes to do outside of the routine of his profession may be the best evidence of his character and genius. Judging Dr. Variclé from this standpoint, and by my own brief glimpse of his intelligent face and winning personality, I shall always remember him as a modern knight errant, chivalrously seeking adventure for the glory of his mistress, Science.—R. W. R.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

'he Central Power-Station of the De Beers Consolidated Mines, Ltd., Kimberley, South Africa.

BY PERCY A. ROBBINS, NEW YORK, N. Y.

(New York Meeting, February, 1908.)

I. Introduction.

The central power-station of the De Beers Consolidated lines, Ltd., was designed and built under my supervision bout five years ago. Since no detailed description of this lant has ever appeared, it may possess sufficient interest to rarrant its publication, even at this late date. Although ome additions may have been made to the plant, the following ccount, prepared from my notes, and accurate up to May, 1905 ıt which time I severed my connection with the De Beers Comany), will, I think, be found substantially correct.

Certain local conditions governing the design of this plant hould be stated first.

II. General Considerations.

The climate is hot and dry. The region around Kimberley arid and water is very scarce. The supply obtained from the nines contains so much material in solution that it is unfit for se in boilers or condensers (although tests recently made with water-softening plant, built by Hans Reisert, of Germany, ould indicate that water thus treated is suitable for boilers). nd the amount of water required for concentrating about 0,000 tons of ore per day is so large that the question of adeuate water-supply for this power-station had to be carefully onsidered.

The rainy season extends from December to April, and the ainfall averages about 15 in. per year. Droughts are frequent; nd in some years there is scarcely any rain at all.

The water-supply for the town of Kimberley is brought from e Vaal river, 16 miles distant, and pumped into town by a ivate water company. The charge made for water, which is

quite suitable for boilers and condensers, is 16c. per 100 gallons.

The cost of fuel, per ton of 2,000 lb., landed in Kimberley, was, in 1905, as follows: Colonial coal having 60 per cent. of the calorific value of Welsh or Pocahontas, 42s. 6d. ($10.20). Natal coal having about 90 per cent. of the value of Welsh, 63s. ($15.12). Welsh and Pocahontas, about £7 10s. ($36.45).

Recently, however, a cheaper coal has become available in Kimberley, owing to a new railway-line which was constructed after I had left South Africa.

Practically all supplies were imported from Europe or America. The sea-freight was about 45s. ($11) per ton; and the railway-charges from the coast to Kimberley about 8s. ($2) per 100 lb.

Burnt bricks, made locally, cost £4 ($19.50) per 1,000 landed at site of the power-station.

Portland cement was imported, and cost from 26s. to 30s. ($6.24 to $7.20) per cask of 400 lb. landed at the power-station.

There was no local building-timber supply. All timber for the De Beers Company was imported from the Pacific coast of America, and cost, delivered at Kimberley, $1 per cu. ft. Fire-bricks were imported from Scotland. All glass, structural steel, piping, mechanical and electrical appliances were imported from America or Europe. Mechanics, masons, etc., received from $4.50 to $5 per day; and shop-work cost from two to five times as much as in England.

The foregoing facts are given merely to show the necessity for economy in design, construction and operation. Fortunately, a supply of native unskilled labor was available at a rate of wages of from 80c. to $1 per day.

In consequence of the high cost of work done locally, the distance from the nearest base of supply (7,000 miles), and the length of time required for obtaining the materials for the plant, it was necessary to design every detail at the outset in order that nothing should be lacking, and that the plant, as a whole, should fit together when erected.

III. Situation of the Plant.

A site, about central in regard to the distribution of power, as chosen at the side of a small pond known as Blankenbergs ei, a shallow depression into which drains the storm-water om a catchment-area of about 6 sq. miles.

Data obtained from some seven years of observation showed at the rate of evaporation of water exposed to the atmosphere d sun's rays averaged about 0.25 in. per day throughout the ar, and during certain months amounted to ⅜ in. per day. ne greatest depth of water known in the pond was about 6 , and, starting with this depth, and considering evaporation take place down to a depth of 2 ft. 6 in., the average surface posed would be about 1,250,000 sq. ft., and the total evapora- on during the 6 months of the dry season would be 27,344,000 perial gallons.

By building a dam across the middle of the pond and storing e water at a depth of 11 ft. on one side of the wall, the aver- ge surface exposed was reduced from 1,250,000 to 800,000 . ft., which reduces the evaporation to 17,500,000 gal., a ving of 10,000,000 gal., which, with water at 16c. per 100 l., represented a saving of $16,000 per annum.

The dam cost about $3,500, and was built from mine-tailings, e side slopes being pitched with waste-rock.

The spot chosen for the power-station site is on a limestone p about 4 ft. thick, overlying a rather soft shale. It was de- ded to build on top of the limestone as far as possible, so as save cost of foundations.

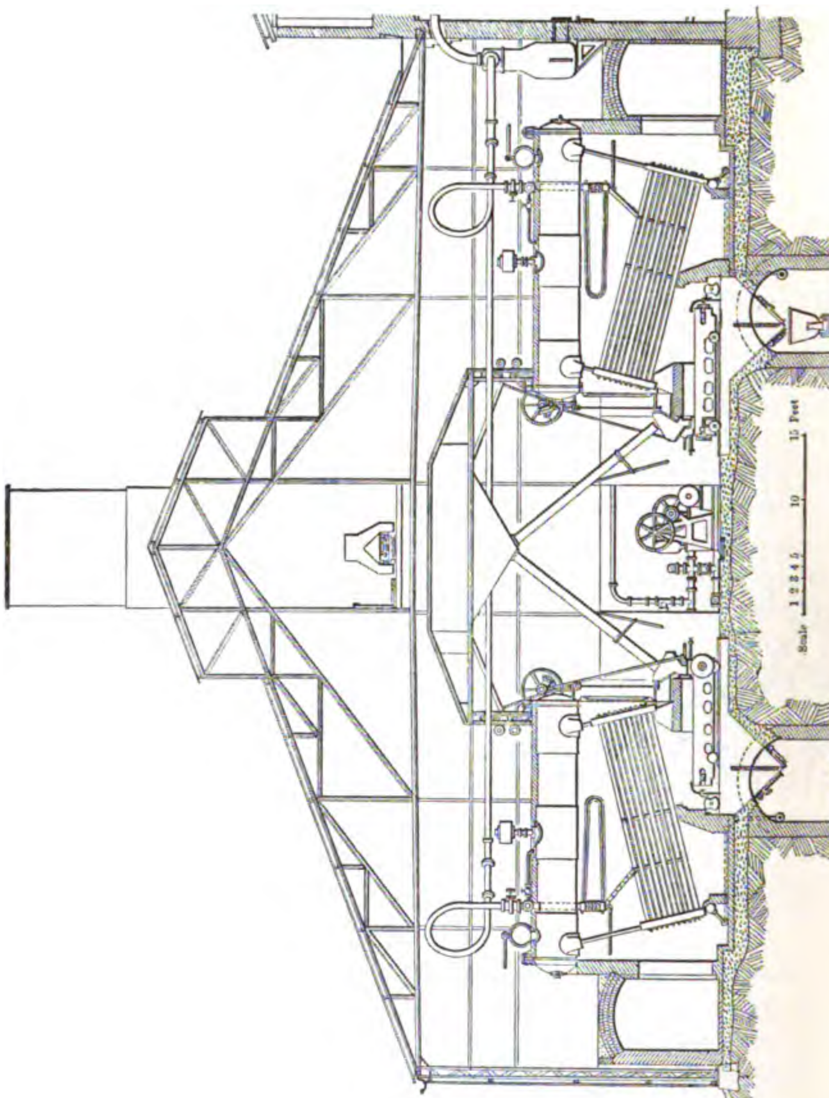
Figs. 1, 2 and 3 show the general arrangement of the power- ation and apparatus.

IV. Buildings.

The main features in designing the buildings were cheapness d utility. In view of the location of the plant, architectural fect was not a consideration.

A brick engine-room was necessary to protect the more deli- te apparatus from the effects of the severe dust-storms fre- ent in this district. For the boiler-house, a steel frame, cov- ed with galvanized iron, was adopted; this type being cheaper an brick. The footing-courses for the engine-house were of salt, taken from a nearby quarry, and stepped into the surface

of the limestone cap. There is a foundation-course of hammer-dressed rock up to an average height of about 6 ft. above ground-level, and above this, the building is of local brick, laid



in cement-mortar, mixed six to one. The bricks used throughout South Africa lay up roughly 3 by 4.5 by 9 in. The division-wall between the engine- and boiler-houses was made 18 in. thick, buttressed at intervals to 27 in. thick. A series of

e arches was sprung along the turbine-room side of this wall support the rail for the electric traveling-crane which spans e engine-room. It was originally intended to carry this rail

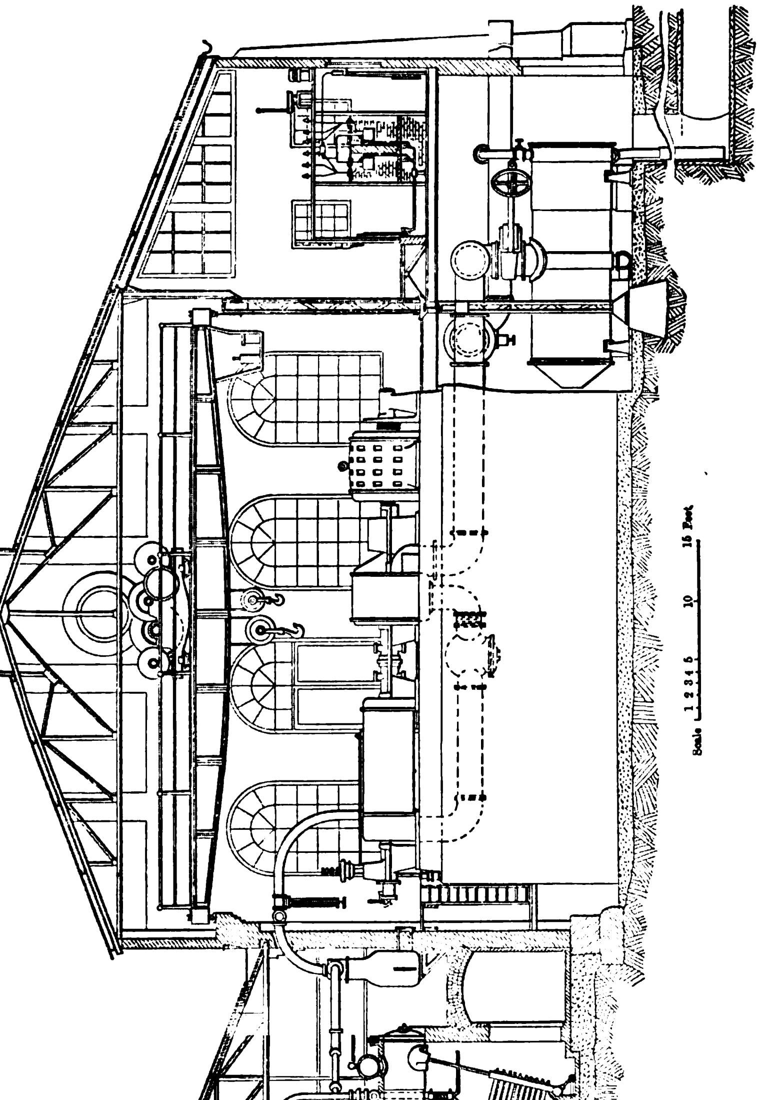


FIG. 2.—SECTION THROUGH TURBINE- AND CONDENSER-ROOMS.

a steel girder resting on buttresses, but, owing to a misunrstanding, this girder was not supplied by the contractors for n-work, and hence it became necessary to form the arches ove referred to. The floor of the switchboard room is sup-

ported at one end by the wall of the building. At the inner end it is carried on steel girders supported by columns resting on concrete blocks at the level of the condenser-room floor. These supporting-columns extend upward to carry the 24-in. steel crane-girder; 8-in. channels are carried up from the height of the crane-girder to support one end of the engine-room roof-

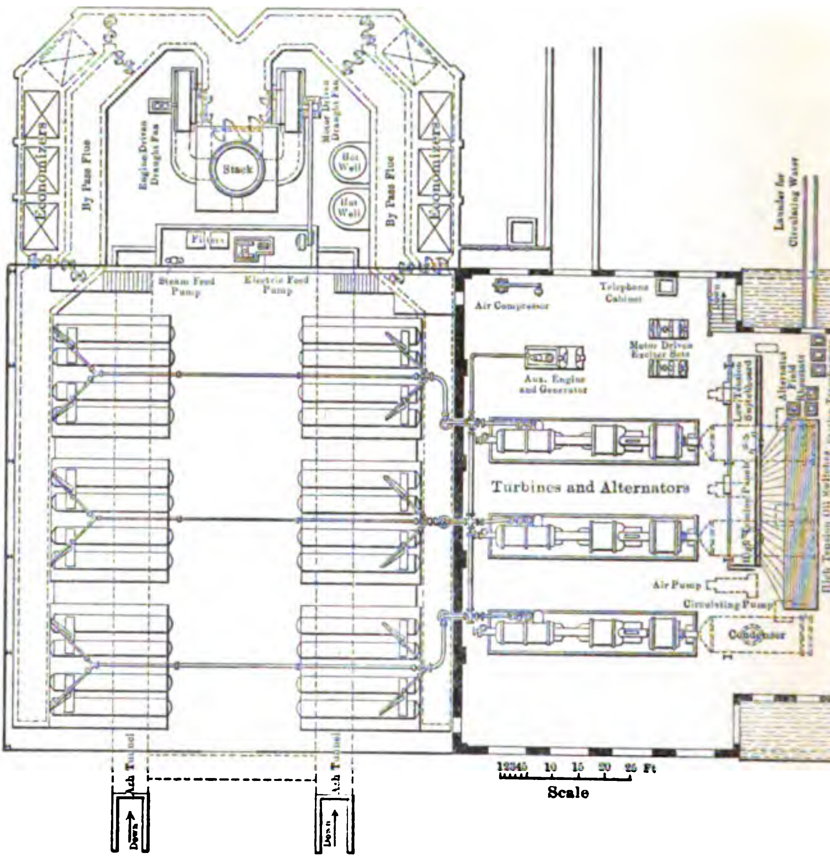


FIG. 3.—PLAN OF POWER-PLANT.

trusses. These 8-in. channels also support the inner end of the steel rafters of the lean-to roof which covers the switchboard room. The engine-room roof-trusses are mild steel, designed to carry the dead weight of the roof plus the live load due to a wind velocity of 100 miles per hour. The roof is covered with No. 24 galvanized corrugated iron, and is ceiled inside with 4 in. by 0.75 in. tongued-and-grooved boards. This wood

ceiling was necessary to avoid the condensation of moisture at night and on cold days. If galvanized iron only is used, the moisture collects in drops and drips down upon the apparatus underneath. A monitor carried by the roof is provided with windows which may be opened or closed from the engine-room floor.

The windows, door-frames, etc., in the brick engine-house were made according to drawings sent to New York, and the building was erected with openings left to receive the fixtures when they arrived. The windows are covered with wire-netting, in order to protect the glass from being broken by the terrific hail-storms which occasionally pass over the country.

The boiler-house consists of a steel frame covered with No. 24 galvanized corrugated iron. The roof-trusses are supported at one end by templates carried in the division-wall between the turbine- and boiler-houses, the outer end being carried on latticed columns. The roof of the boiler-house is not ceiled. The floor in the boiler-house was laid in concrete.

The floor of the engine-room is of wood, although it was my intention to replace this floor with reinforced cinder-concrete carried by steel girders. The floor of the switchboard room is of concrete, laid over sheet-iron forms sprung between the supporting floor-girders. The condenser-room floor is like that of the boiler-house.

V. Coal-Handling Plant.

The coal-cars are pushed into a siding and the coal unloaded by hand over the side of the car into heaps. Small 20-cu. ft. side-tipping mine-cars are loaded by hand from these heaps and then pushed around to the coal-crushers. Plans had been developed for mechanically unloading the railway-cars, stacking the coal and afterwards removing from stacks to crushers, but this work had not been carried out at the time I left Kimberley. The crushers consist of two pairs of pony-rolls made by the Dixon Manufacturing Co. These rolls have hardened steel, diamond-pointed teeth which break the coal up into a size suitable for burning—namely, not greater than 1-in. cubes. One pair of rolls is set slightly further apart than the other. This is found necessary in crushing different grades of coal, as certain classes of harder coal break too fine when passed

through close-set rolls. The rolls discharge on to a 20-in. Robins belt-conveyor, which rises at an angle of 21° until it reaches the height necessary to discharge into the hoppers over the boilers. So long as there is a sufficient quantity of coal on the belt the coal rides quietly and does not roll back, but when the belt is nearly empty, small round pieces have a tendency to roll about and eventually fall off. This same difficulty, experienced also in another plant I designed, was overcome by driving the belt from the bottom end, and making it horizontal for about 10 ft. at the point where the coal is delivered to it. The trouble in the present instance, however, was not sufficient to warrant the expense of making this change. The coal is discharged from the belt into hoppers by means of an automatic tipper supplied by the makers of the belt.

Sufficient bin-capacity is provided to hold an 8-hr. supply of coal. The bins are designed for stresses of 14,000 lb. tension, 12,000 lb. compression, and 10,000 lb. shear on rivets. The coal is drawn from the bins to the furnace-hoppers through square chutes, shown in Fig. 5.

The chutes are spread at the lower ends into two branches. At the junction of these branches with the main chute is fitted a gate-valve for cutting off the flow of coal. The branch chutes are made detachable in order to permit the boiler-fronts to be swung open.

VI. Boilers.

Boilers of the Babcock & Wilcox type had been used extensively by the De Beers Co. in previous work, and were thus thoroughly understood by the employees of the company. The straight tubes facilitate repairs, cleaning and inspection,

There are 12 boilers, each of 3,580 sq. ft. of heating-surface, set in six batteries.

Each boiler comprises 16 sections or slabs, containing 10 best, wrought-iron, lap-welded tubes, 4 in. in diameter, and 18 ft. long, connected at the ends by continuous wrought-iron staggered headers, or "up takes" and "down takes;" the tubes being fastened therein by being expanded. Each "header" is provided with hand-holes placed opposite the end of each tube, of sufficient size to permit the cleaning, removal

nd renewal of a tube and having a cap fastened with wrought-ron bolt and clamp and cap-nut. The several sections are onnected at each end to two steam- and water-drums, and at ne end with a mud-drum, by means of wrought-iron lap-velded tubes, 4 in. in diameter and of suitable length, the oints being made with an expander.

The steam- and water-drums are 42 in. in diameter and 23 . 7 in. long, made of mild steel plates $\frac{7}{16}$ in. thick, the longi-udinal seams being double riveted; at one end is a manhole, lso a nozzle for a safety-valve and a second one for taking off eam, 5 in. in diameter, with 12 in. flange, faced and drilled.

The two drums for each boiler are joined at the rear end ith a steel-riveted cross-drum 20 in. in diameter, fixed to the ain drums by expanded connections.

The mud-drums are of special cast metal, 10 in. in diameter nd 116 in. long, with hand-holes and a nozzle for blow-off ipe, fitted with a Hopkinson 2.5-in valve.

The boilers are suspended from wrought-iron girders, rest-g on wrought-iron columns, with cast-iron bases properly ecured so that the weight is sustained entirely independent of e brick-work. This arrangement permits free expansion or ntraction and removal or replacement of the brick-work, if quired, without disturbing the boilers or connections.

Each boiler is provided with two "dead-weight" safety-lves set to blow at 147 lb., one steam-gauge, dial 12.5 in. in ameter, two sets of asbestos-packed Reflex water-gauges, two 25-in. feed check-valves, one 2-in. feed stop-valve, one 2.5 in. opkinson blow-off valve, one 0.75-in. cleaning-valve, and one in. main stop-valve.

The fronts of the boilers are of ornamental pattern, contain-g large doors for access to the ends of the tubes, and the posed brick-work is white enameled.

The boilers were designed for a working-pressure of 145 lb. r sq. in.

The tube sections and mud-drum were tested and made ght under a hydraulic pressure of 300 lb. per sq. in., and the eam- and water-drums under a hydraulic pressure of 225 lb. r sq. inch.

Each boiler is fitted with a Babcock & Wilcox patent super-eater designed to superheat the steam 75° F. It is an open

question in my mind whether it would not have been advantageous to install separately-fired superheaters so as to permit independent control over the temperature of the steam. However, the superheaters have been operating for more than two years, and no trouble has been experienced with them.

Each furnace is fitted with two chain-grate stokers supplied by the makers of the boilers, and different qualities of coal have been burned with equal facility, the stokers giving perfect satisfaction during the period covering the running of the plant, a fact all the more striking when it is considered that no men experienced in the operation of mechanical stokers were available at the time the plant was put into operation.

These mechanical stokers possess the inherent fault that they permit too much cold air to get into the combustion-chamber. If, however, as in the present instance, the boiler-capacity is ample, a low draft may be used, and with careful attention to the rate of feed and thickness of fire, a condition of efficient working may be maintained.

The ashes are delivered over the inner end of the stokers and fall into a hopper over the ash-tunnel. The fine coal which falls through between the stoker-bars is pushed by hand, from time to time, into a separate compartment of the ash-hopper. The ashes are drawn out through one door and the fine coal is drawn out through another. Originally it was intended to provide a mechanical ash-handling plant, but it was decided that a mule, on the end of a rope attached to the ash-cars, makes the most economical and inexpensive ash-conveyor for a plant of this size. The cars containing the ashes are drawn up an incline to the surface by the mule, trammed out to the ash-dump and there tipped. The fine coal is drawn up an incline to the surface and tipped into the coal-handling plant, by which it is elevated to the hoppers above the boilers.

The gases from the boiler pass into flues built on ground-level, and thence to one end of the station where the economizers are placed. The flues are of ordinary burned brick, lined with 4.5-in. of similar brick bonded at intervals into the flue-walls. As plan, Fig. 3, shows, the boiler-house is divided into halves, each containing six boilers, a flue common to all

ix boilers, a set of economizers, and a draft-fan which discharges nto the base of a stack, which latter is common to the entire oiler plant. The economizers are by-passed by flues extending t one side. Where necessary, the thrust of the flue arches is aken up by tie-bolts bolted through washer-plates on the outside f the flue-walls. Inside of the flues, where exposed to the action f the gases, these tie-bolts are protected by wrought-iron ipes. Access to the flues is had through cast-iron doors built nto the brick-work. The flues are carried around into the ase of the stack, as shown in Fig. 3, in order to bring the raft-fans inside of the area adjacent to the end of the boiler-ouse.

There are two draft-fans, supplied by B. F. Sturtevant & Co., ach inclosed in a three-quarter housing, one driven by an en-ine direct-connected to the fan-shaft, while the other is belted a 30-h.p. induction motor. These fans are located on opposite des of the stack-base, the electrically driven one generally be-ng used.

The stack-base, of burnt brick, has no fire-brick lining. The ack consists of an outer shell 10 ft. in diameter, built up of eel plates with lap joints and lined throughout its length with in. of ordinary burned brick, a 2.25-in. air-space being left etween the brick lining and the plates. Although not neces-ary, since its base was sufficiently broad to resist overturning om any ordinary wind pressure, the stack was stayed with ur wire-ropes anchored in concrete blocks.

The general arrangement of economizers, fans and stack is own in Fig. 3.

As already noted, there are three sources of water-supply—amely, hard water from the mines, river-water from the Vaal ver and storm-water conserved in dams.

At the time of designing the plant it was not considered ad-sable to use the mine-water for boiler-purposes. The Vaal ver supply is led up to the power-station through a 4-in. main. he supply from the vlei is pumped into the filters by a small ree-throw pump located on the condenser-room floor. The ater is elevated to a filter-tank placed at the base of the stack.

The water-supply piping, shown in Fig. 4, was designed so as bring, as far as possible, all of the valves controlling the fferent supplies together, in order to facilitate changing from

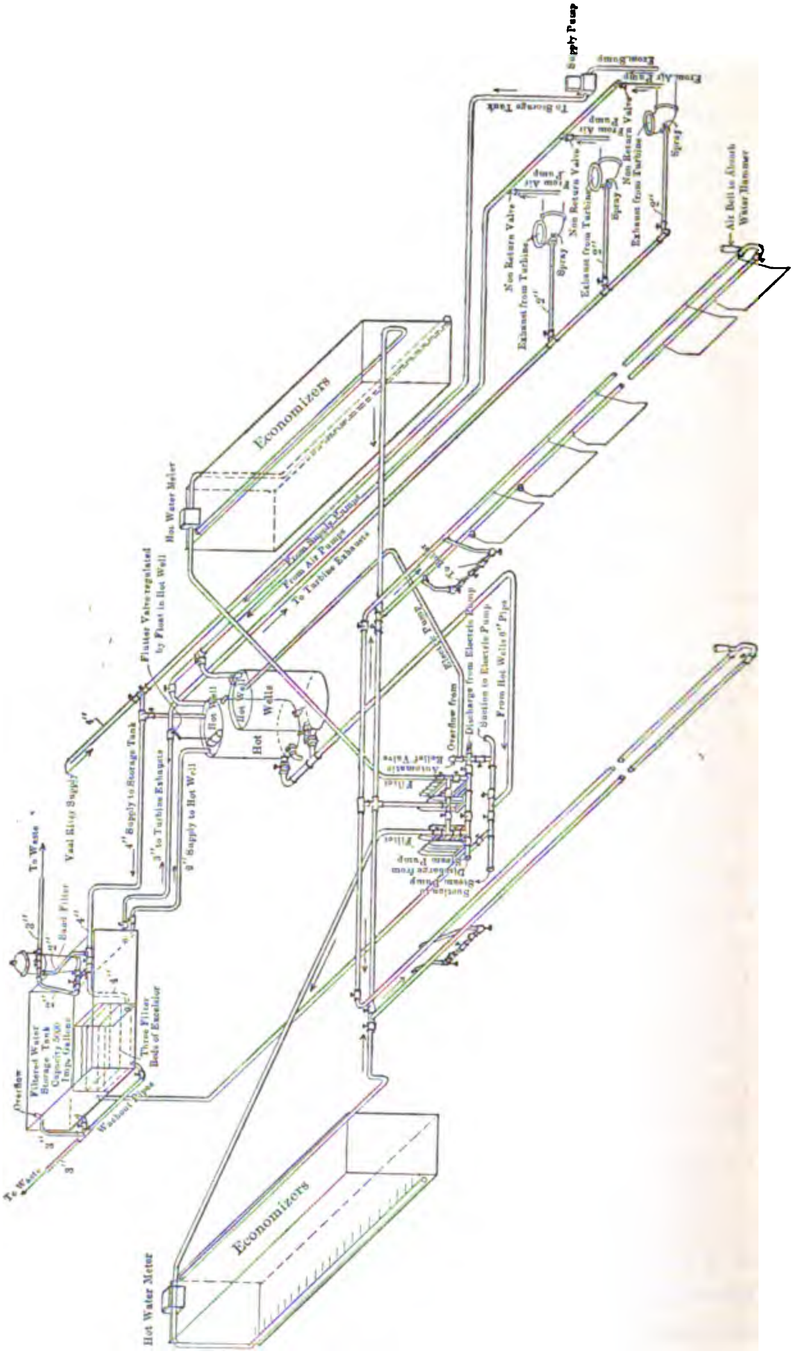


FIG. 4.—SCHEME OF WATER-PIPING.

one to another. All water which enters the station is thoroughly filtered before reaching the boilers. It first passes through a crushed-quartz sand-filter, thence to the bottom of a tank containing three coir mattresses arranged one above the other, and upward through these mattresses, finally overflowing into the main storage-tank. The piping is so arranged that any part of the filtering-apparatus may be by-passed during cleaning or repairing. There is also a connection with the hot-well by means of which water may be led directly into the hot-well without going through the filters. There are two hot-wells arranged as shown, made of boiler-plate riveted in cylindrical form, each being 6 ft. 1.25 in. in internal diameter by 8 ft. in depth, and insulated on the outside with 9 in. of brick-work. These wells are arranged in duplicate in order to permit continuous running while cleaning. The hot-wells stand on the level of the boiler-room floor, so as to insure that the suction of the feed pumps will be submerged. It was found necessary to cover the tops of the hot-wells with iron gratings, in order to prevent employees from falling into them. Several fatal accidents had already occurred from this cause in the works of the De Beers Company.

There are two feed-pumps, one electrically and the other steam-driven. The former is a vertical, three-throw, with outside-packed plungers 5.5 in. in diameter by 8-in. stroke, and runs at a speed of 45 rev. per min., and is geared direct to a 5-h.p. induction motor, the pump and motor being mounted upon a common bed-plate.

The delivery of the pump is fitted with an air-bell and an automatic relief-valve, the latter having its overflow connected with the hot-well in order to return to the hot-well any excess of water delivered by the pump.

The steam-pump is a Weir tandem-compound, with high pressure steam-cylinder 10 in. in diameter, low pressure steam-cylinder 18 in. in diameter and pump-barrel 10 in., all with a common stroke of 25 inches.

The electrical pump is run about 10 hr. per day, being supplemented by the steam-pump during overloads. During periods of small loads on the station the steam-pump is used.

The suctions of the pumps are below the water-level in the hot-wells, thus insuring that they shall be always flooded.

The pipe-connections between the pumps and the feed-ranges are shown in Fig. 4, the connections being so arranged that either pump can deliver its water through filters and economizers, or direct to feed-ranges above the boilers. The filters between the pumps and the boilers consist of a number of cylindrical chambers, each containing a perforated copper tube covered with a stocking of Turkish toweling. The water passing through this toweling leaves behind any impurities which may have remained after the preliminary filtering. From the feed-pumps the water passes through the filters to hot-water meters and thence to the economizers, which are in two sets, each of 320 tubes, one for each side of the boiler-house. The economizers are of standard Green construction, with vertical cast-iron tubes forced into cast-iron headers. From the economizers the water passes into the feed-ranges over the boilers. There is a double set of feed-pipes so as to avoid shut-down in event of repairs being necessary to one range. An air-bell is located at the extreme end of each range to take up any water-hammer or other sudden fluctuations in pressure. The air-bells are provided with air-discharge cocks.

The tops of the economizers are covered with asbestos mats about 2 in. thick. The scraper-gears are driven by 2-h.p. induction motors placed over the economizers, the scrapers being run at intervals during the day.

Water is delivered from the economizers at a temperature of about 220° F.

The feed piping is 4-in. heavy lap-welded pipe with heavy cast-iron flanges, and between the economizers and boilers it is insulated with a covering of flake mica, 2.25 in. thick, so as to prevent radiation of heat.

The arrangement of steam-piping, given in Fig. 1, shows that the steam from each boiler stop-valve passes through a full loop bend before reaching the straight-through connections which lead to the separators. This arrangement was followed, as I wished to avoid any thrust on the turbines, due to expansion of the piping. It will be readily understood that any expansion in the loops will tend to open them out, and cause a slight tension on the piping to the turbines, thereby relieving the turbines of any deleterious thrust. In practice it is found that the turbines, when heated, expand about $\frac{5}{16}$ in.

length, and as this expansion is in the direction of the boiler-ouse any stiff arrangement of piping would be almost sure to stort the turbine-cylinders and cause trouble.

No attempt was made to provide against vibration in the ping until after a trial run had been made, so as to enable servations to be made which would insure the proper placing the anchor-bolts and stays.

The turbines admit steam in pulsations at the rate of about 1 per minute.

Owing to the loop bends in the piping above the boilers the hole piping-system may be regarded as a pendulum. The tural period of vibration of the loops themselves would be proximately 1 sec. It would therefore be expected that when e pulsations of steam admitted to the turbines came into syn-ronism with the natural vibrations of the piping, harmonics ould be set up in the piping which would cause maximum brations to take place. This effect was found to be true, e periods of maximum vibration being followed by periods of iescence.

The vibration due to these harmonics was not in itself of any eat magnitude, in fact were it not for other causes it would rdly have been necessary to anchor the piping. Separators, ained by steam-traps, were installed between the turbines d their boilers, and occasionally a trap will hang up and ow the water-level in its separator to rise to a point where the riod of vibration of the inclosed body of steam is such as to use the separator to act as a resonator to the vibrations of the ping-system. Under this condition, the vibration of the pip-g becomes very marked.

All troubles due to vibration were eliminated by careful ying and anchoring, without interfering with expansion, and ere has scarcely been a leaky joint in the steam-piping system ring the two years of operation of the plant.

All steam-piping is covered with 2.5 in. of corrugated flakes mica held together in wire-netting forms, bent to fit the pipes, d covered on the outside with heavy canvas.

At full load, condensing, each turbine requires about 21,000 of steam per hr., which corresponds to a velocity of slightly s than 4,000 ft. per min. in the 7-in. piping. In the 6-in.

pipes, connecting opposite pairs of boilers, the flow is about 3,500 ft. per minute.

The steam-piping is of extra heavy lap-welded mild steel, and all bends were rolled hot from best quality of extra heavy lap-welded steel-pipe. All piping was set up and measurements checked before shipping from England, the various parts being marked with numbers indented in the metal, and all flanges prick-punched so as to facilitate identification at Kimberley. Due allowance was made for jointing with corrugated copper gaskets, which lie entirely within the bolt-circles. All joints are male and female.

The pipes and fittings were guaranteed against a hydraulic test-pressure of 250 lb. per sq. inch.

The steam from each battery of boilers passes through a Stratton separator made of mild steel plate and containing a volume of 30 cu. ft. Separators are located in the boiler-house over the flue, where the air is always warm, thus insuring a minimum of radiation, and loss of heat is further provided against by a covering of mica-plaster 2 in. thick. Each separator is fitted with two Hopkinson water-gauges, one placed in the turbine-room, its connections being carried through the wall, thus enabling the engineer in charge of the turbine-room to keep an eye on the water in the separators.

Steam-traps drain the separators into the hot-wells.

VII. Steam-Turbines.

At the time when the power-station at Kimberley was designed, the use of steam-turbines was very limited, and the only large machine which had been built for driving an electrical generator was the one supplied by Messrs. C. A. Parsons & Co. for the Electrical Supply Works of the city of Elberfeld, having a rating of 1,000 kw. at full load.

The tests on this machine, together with the data available on smaller machines, determined me in my choice of turbines for the prime-movers in the station.

Briefly, the advantages in favor of turbines for central power-station work are:

1. The cost, installed, is less than that of first-class reciprocating-engines of the same full-load efficiency.

2. At light loads, and hence for constant running 24 hr. per

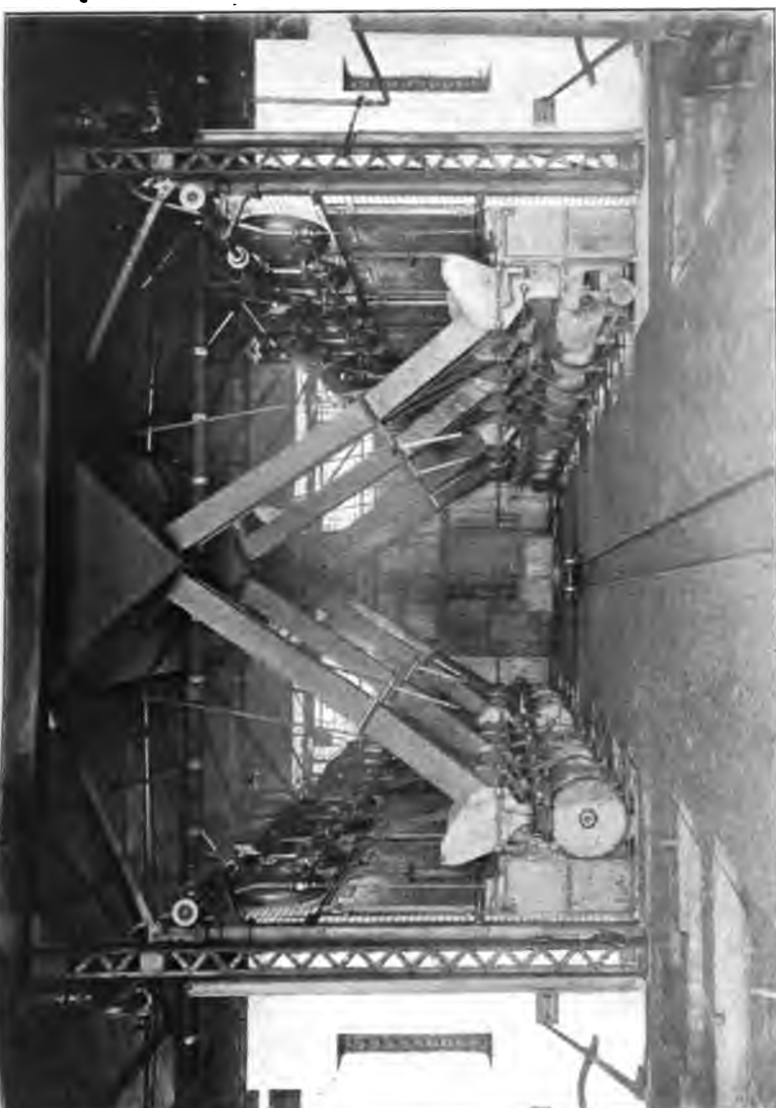


FIG. 5.—VIEW IN BOILER-ROOM.

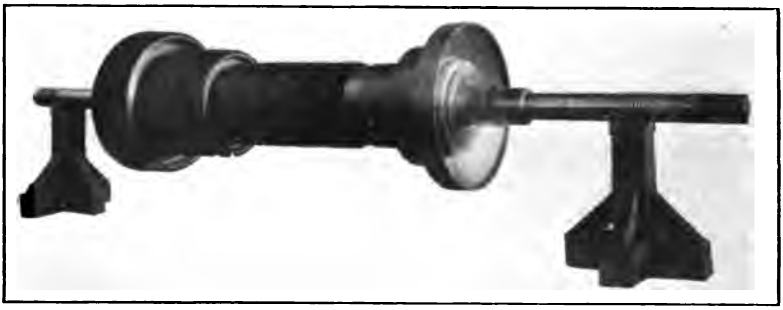


FIG. 6.—HIGH-PRESSURE TURBINE SPINDLE.

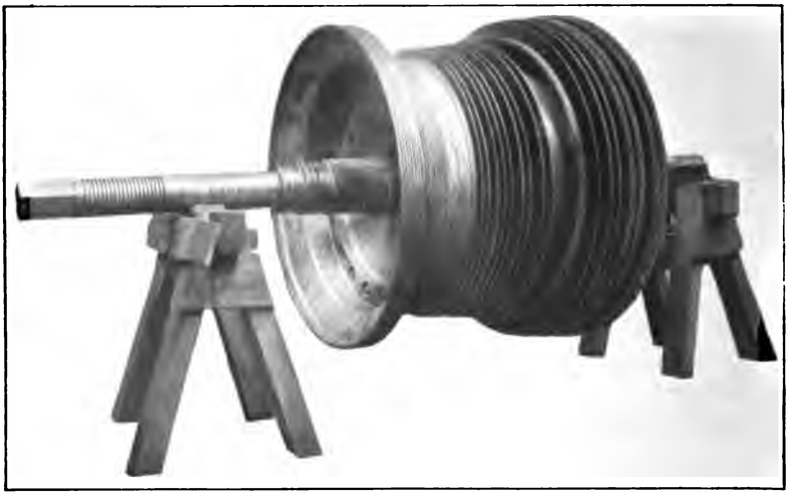


FIG. 7.—LOW-PRESSURE TURBINE SPINDLE.

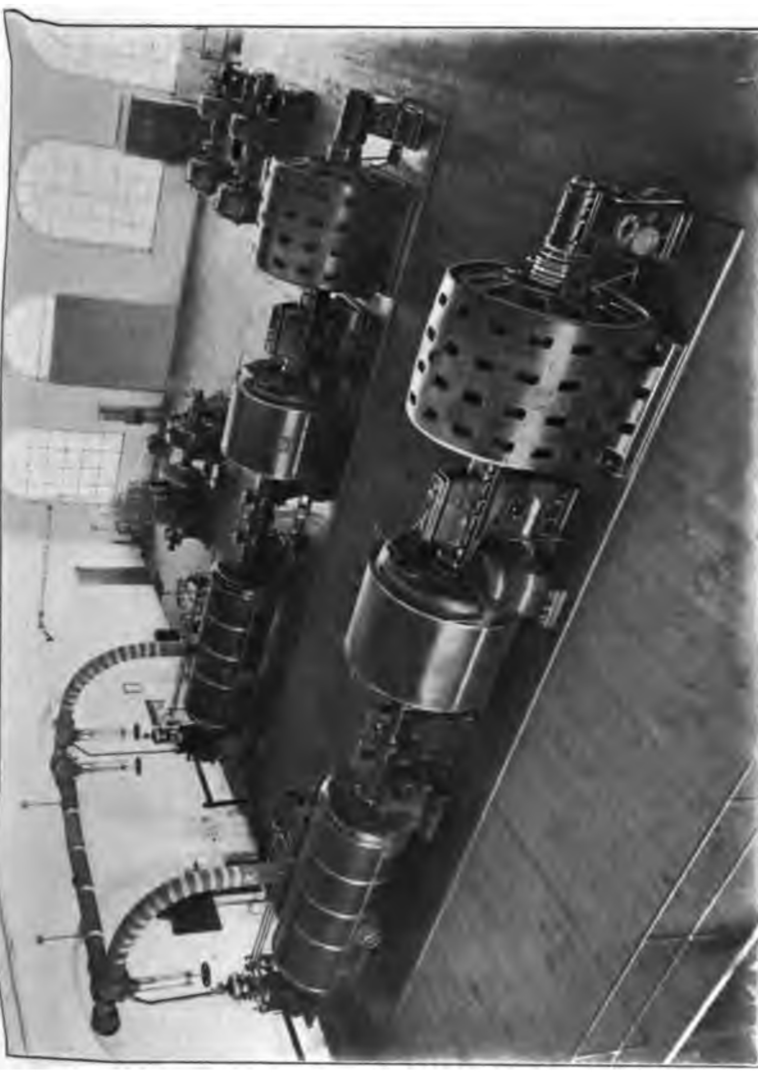
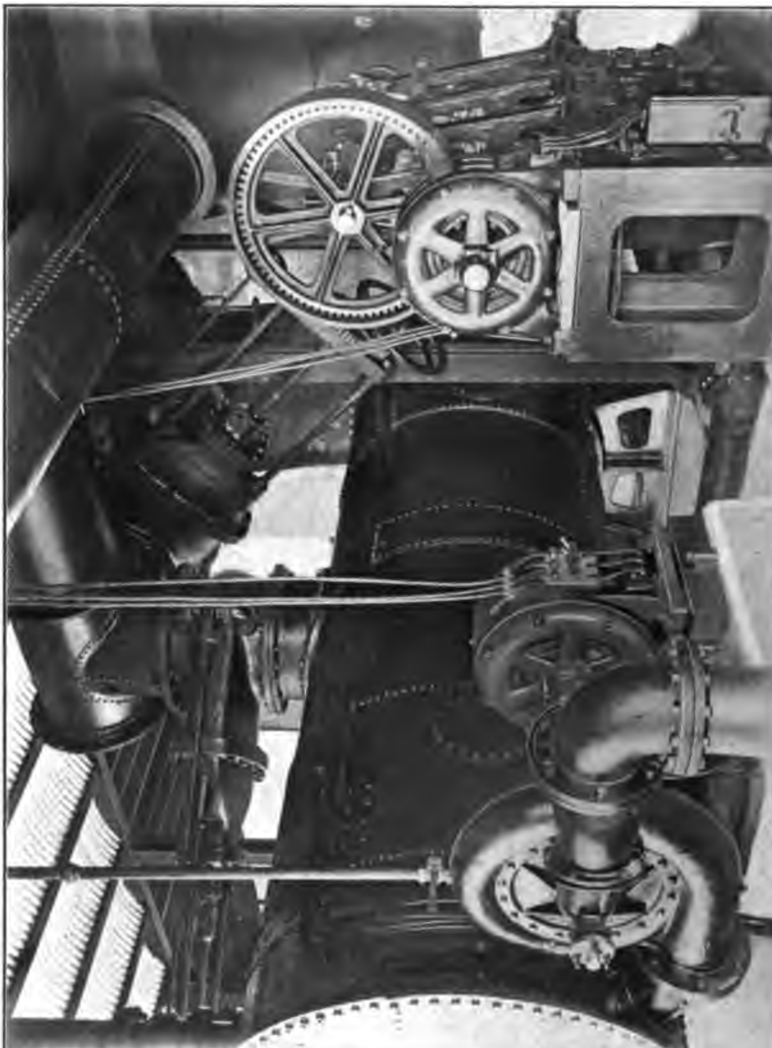


FIG. 8.—VIEW OF TURBINE-ROOM.



ay, the turbine consumes less steam per kw. output than does reciprocating-engine.

3. The cost of maintenance on turbines is considerably less an that of reciprocating-engines.

4. There is no cylinder-lubrication, and hence the water turned from the condensers to the boilers may be kept practically free from oil; the only oil which finds its way into the eam in this class of turbine being that used to lubricate the earing-parts of the admission-valve and its relay—a very significant quantity.

The principal reasons, however, in favor of turbines are electical, especially the constancy of speed, due to the high angular locities of the moving parts. I have stood by a turbine carryg 25 per cent. overload and have failed to detect any change the hum emitted when the whole load was suddenly thrown f, and, after an interval, thrown on again.

Careful tests show that the variation in speed between no ad and full load is only 2 per cent., and when full load is iddenly thrown on or off, the turbine settles down to a conant speed in less than 2 sec. of time.

A peculiar advantage possessed by turbine-driven alternars is the fact that in a station carrying heavy inductive loads, e spare machine makes an excellent power-factor regulator hen run as a synchronous motor.

In this connection I submit a few extracts from Mr. R. S. Iansel, Electrical Engineer of the De Beers Explosives Works, ear Cape Town, of which I designed the power-plant, conining three 400-kw. Parsons turbines and 3-phase generators. The extracts from the letter are:

"Up to the present our large motor-load has had a very low power-factor, rely exceeding 70 per cent.; for this reason it has been impossible to get more an 300 kw. out of any one of our machines, owing to the excessive drop in oltage . . . . By synchronizing the spare machine, shutting off the steam in s turbine and giving its generator a heavy field-charge, we have succeeded in ising the power factor to 85 per cent., and now have no trouble in getting the ll rated overload from the generators supplying power to the works."

The impracticability of using an engine-driven generator in is manner will be readily understood, on account of both the echanical and the electrical difficulties. During my stay in Kimberley, the opportunity of trying the experiment on the

1,000-kw. generators did not present itself, since the load on the station grew so rapidly that there was never a spare machine.

I have taken space to explain this advantage, not so much on account of its importance, but because I have never seen any published reference to this matter. It will be understood that the generator-iron must be designed with a low flux-density (a peculiarity of turbine type machines) in order to accomplish the desired result.

The turbines and generators at Kimberley were supplied by the Westinghouse Co. and are of the two-cylinder type. Steam is expanded through a series of blades contained in what is known as the high-pressure cylinder, whence it passes into a low-pressure cylinder. The high- and low-pressure spindles are shown in Figs. 6 and 7 respectively, while Fig. 8 gives an interior view of the turbine-room.

There are three turbine-units, each consisting of a Westinghouse-Parsons steam-turbine, direct-connected to and mounted upon the same shaft with one 3-phase alternating-current Westinghouse generator. Two of the units have a capacity of 1,000 kw. useful energy output, working under an inductive load having $\cos \theta = 0.85$. The third set has a capacity of 1,500 kilowatts.

Steam is delivered to the turbine at 145 lb. pressure and 75° F. superheat.

The current from the generators is delivered at 5,000 volts pressure.

The turbines are of multiple-expansion, parallel-flow type, each machine consisting of two turbines, arranged in tandem compound. The steam distribution is such that when working under full load the high- and the low-pressure turbines develop approximately equal power. The speed of all three machines is 1,500 rev. per minute.

The maximum length of turbine, including generator, is 42.9 ft.; maximum width, 7.8 ft.; maximum height over largest diameter, 6 ft.; height to top of governor, 8 ft. The total shipping-weight is 130,000 lb., the weight of the heaviest piece being 45,000 lb. For carrying overloads, a by-pass is provided for passing high-pressure steam into the low-pressure turbine, by means of which an overload of 50 per cent. may be carried.

The cylinders are made of close-grain cast-iron, designed so

that at no time shall the tensile stress exceed 2,000 lb. per sq. inch.

The shafts are of high quality mild steel, having mounted thereon cast-steel rings for carrying the turbine-blades. The maximum stress in the shaft, due to bending and twisting movements, does not exceed a fiber-stress of 8,000 lb. per sq. inch.

The blades are of bronze, calked into dove-tail grooves in the cylinders and in the steel rings upon the shaft. The longitudinal distance between the stationary blades and the revolving blades is about $\frac{5}{16}$ in. The clearance between ends of moving blades and cylinders, and between the ends of stationary blades and rotating parts, varies from 0.01 to 0.04 inch.

The bearings are of gun-metal and consist of two concentric sleeves mounted upon the shafts, the shaft being free to revolve within the inner sleeve, and the latter being free to revolve within the outer sleeve. Thrust-bearings are provided, fitted with adjustment-screws, which permits the shaft to be moved longitudinally.

A sensitive governor is provided with each turbine, which holds the speed practically constant under all loads; the action of this governor may be assisted by hand during the synchronizing of the generators. A safety governor also is provided for each turbine, which automatically shuts off steam when the speed rises above a certain predetermined point.

A throttle-valve is also provided with each turbine.

The cylinders are lagged with loose asbestos contained in wire sacks, the whole being inclosed in cases of planished sheet-steel.

Some trouble has been experienced in lubricating the turbine-bearings, which could have been avoided if the requirements had been better understood at the outset. In order to secure efficient lubrication it is only necessary to provide means for cooling the oil after it has been through the bearings, which can be easily accomplished if there is a supply of cheap cold water available. At Kimberley, however, it was necessary to save the cooling-water, and for this purpose a small cooling-tower was erected, through which the circulating-water is dropped after extracting the heat from the oil. The oil flows through the bearings to a small pump, driven from the turbine-shaft by gearing, which forces the oil through coils located

in the turbine-base, the cooling-water circulating around the coils.

Since the erection of an efficient cooling-tower for the water, the trouble with the bearings has disappeared, and after two years of almost constant service, the turbine-shafts and bearing-sleeves show scarely any wear, the original tool and oil-stone marks still being in evidence.

It will be well, however, for prospective users of turbines to give the question of oil-cooling careful study.

Before shipment from Pittsburg, the two 1,000-kw. sets were thoroughly tested for steam-consumption by the late Dr. R. H. Thurston and Mr. H. H. Norris, of Cornell University, the results being as follows:

Load on generator (kw.),	269.7	495.5	752	1013	1247
Steam-pressure (lb.),	143	142.5	142.5	138	140.9
Vacuum (lb.),	28.24	28.30	28.18	27.96	27.55
Superheat (°F),	77.6	84	75.3	59	75.2
Steam per electrical h.p. per hr.,	19.27	15.58	14.73	14.22	13.67
Barometer (in.),	29.2	29.25	29.3	29.3	29.2

These data make a good showing concerning the steam-consumption per e.h.p. delivered, and when it is considered that these turbines were among the first of any size built by the Westinghouse Co., the performance is all the more creditable.

The condensers for the plant were made locally, by utilizing the shells of some old fire-tube boilers. Calculations for cooling-area were based upon the assumption that cooling-water would have an initial temperature of 80° F., and an allowance was made of 4.25 sq. ft. of condenser cooling-surface per kw. capacity of turbine. Subsequent results tend to show that a slightly greater area would have been advantageous, due to the fact that the condenser-tubes become quickly coated with a layer of slime, which detracts from their efficiency.

The condensers are counter-flow, *i. e.*, the steam enters at the top and the condensed water discharges at the bottom, while the circulating-water enters at the bottom and discharges at the top. Fig. 9 shows one of the condensing-sets and the arrangement of circulating- and air-pumps.

The in-take tunnel for the condensing-water is provided with a double screen made of perforated plates for keeping out grass

ıd frogs, and the suctions to circulating-pumps also are proided with screens.

The circulating-pumps are 9 in. centrifugal, each being riven by a 30 h.p. motor.

Air-pumps are of the Edwards type, each having 3 buckets 4 in. in diameter by 12-in. stroke, the crank-shaft making 50 rev. per min. Barrels, buckets, valve-seats, etc., are of rass. Bucket-rods are rolled bronze. Crank-shaft is mild ;eel, machined all over, and carried by four cast-iron "A" ames.

Each air-pump is fitted with a small water-pump, to take the ater from the main pump and force it up to the hot-well.

The circulating-water from the condensers is elevated to a eight of 14 ft. above the condenser-room floor, and discharged om the end of the building into an open-air launder 1,200 ft. ıng, made of rough sawn boards with feathered joints, having fall of 10 in. in 100 ft. It discharges into the storage-pond the corner farthest from the intake to condensers, a distance f 1,000 ft. By this means the water in the launder flows ,200 ft. at a high rate of flow, turning over and over and ınstantly coming in contact with the atmosphere, and afterards flows slowly across the pond back to the condensers. ooling is thus effected largely by radiation. A cooling-tower epending upon evaporation for cooling might give better esults, but the loss of water would be excessive, and water is arce in Kimberley.

In order to utilize as much of the heat of the exhaust steam possible, all make-up water for the boilers is injected into ıe exhaust-pipes from turbines, as follows:

A float is suspended in the hot-well by means of a rod tached to the crank of a flutter-valve. This valve is in a pe-line which connects at one end with the bottom of the tered-water storage-tank, and has branches to each exhaust pe immediately under the turbines. As the water-level in e hot-well drops, the flutter-valve opens and allows the cold ake-up water to be injected as a spray into the exhaust steam om the turbines—an effect which has the dual advantage of ıproving the vacuum and at the same time raising the temerature of the make-up water. An increase in vacuum has een noted due to the use of the spray.

The exhaust-piping, shown in Fig. 2, has an atmospheric exhaust-valve placed between the main exhaust from each turbine and an atmospheric pipe so as to prevent any extraordinary pressure from rising in the low-pressure turbine in event of the failing of the condensing-plant.

All exhaust-piping is riveted wrought-iron, the 30-in. piping made of 0.25-in. plate, and the 24-in. pipe of $\frac{3}{16}$-in. plate. Pipes were made in halves with longitudinal divisions, the longitudinal seams being left unriveted so as to permit the pipes to be nested for shipment, the butt-straps being riveted to one of the half sections. Flanges are of cast-iron riveted to the pipes.

All bends, tees, etc., are riveted up out of bent plates, in order to lighten the fittings as much as possible, and lessen the transportation-cost to Kimberley, which was $2 per 100 pounds.

All valves are double-seated gate-valves, fitted with renewable seats and by-passes, the operating-spindles being geared to the valve-stems.

VIII. Electrical Equipment.

Power is delivered from the generators at 5,000 volts pressure, 3-phase, 50 cyles per sec., the generators having slot-wound stationary armatures with star-connected windings.

The revolving fields are 4 pole and the potential of the exciting current is from 80 to 100 volts. Under test, the 1,000-kw. generators developed the following characteristics: Drop in pressure from no load to full load at 85 per cent. power-factor was 12.4 per cent.

The efficiency was, with quarter load, 82.5; half load, 90.3; three-quarters load, 93.05, and full load, 94.4 per cent.

The principal loss, as would be expected in generators of this type, is in the iron of the armature-core, this loss constituting 82.75 per cent. of the total loss at full load; or, expressed in terms of the full load, core-loss equals 4.6 per cent.

Current for field-excitation is delivered from two motor-generator sets, each consisting of one 50-h.p. induction motor, 3-phase, 220 volts, mounted on the same bed-plate with and direct-connected to a 37.5-kw. Westinghouse generator, which delivers direct current at a pressure of from 80 to

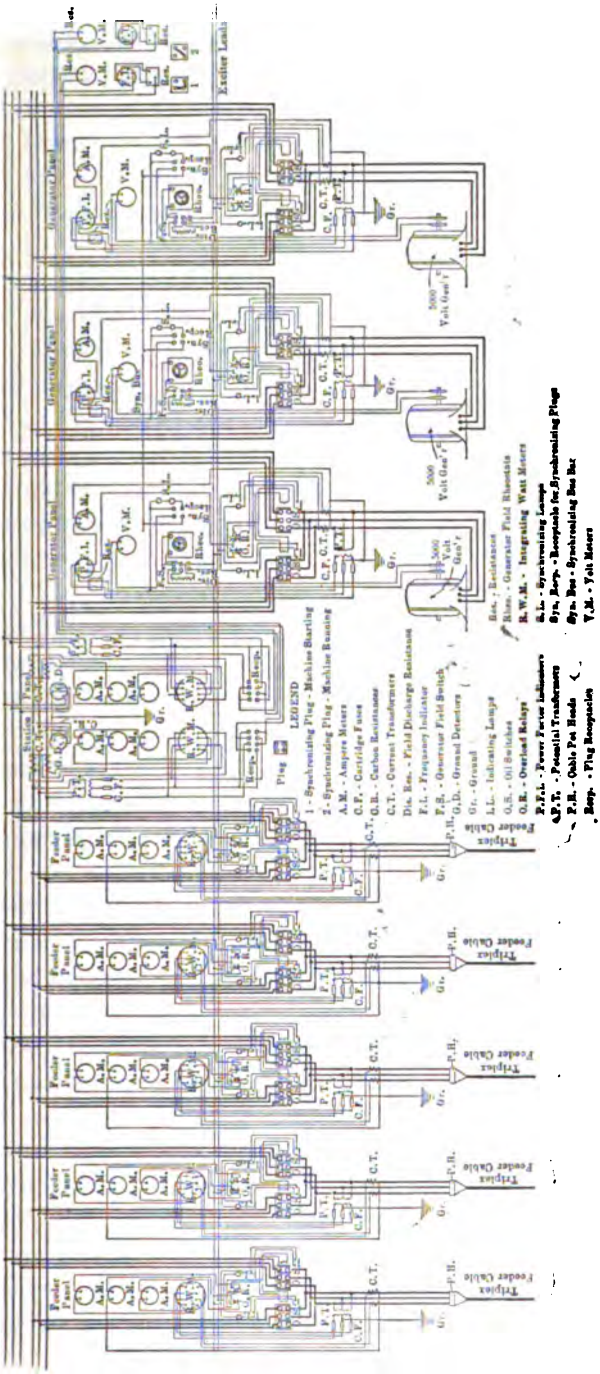


FIG. 10.—HIGH-TENSION WIRING-DIAGRAM.

100 volts. Current from the generators is led to the switchboard by triplex lead-covered cables carried under the floor.

The 5,000-volt switchboard is of the standard construction of the General Electric Co., and the wiring is shown in Fig. 10. The current for the various instruments is converted to a safe pressure by transformers placed along the back of the wall and accessible for renewing fuses from the insulated platform which extends over the wiring-connections.

Switches, immersed in oil-tanks contained in separate brick compartments, are operated through wood and iron rod connections, by levers on the front of the marble board.

Two sets of bus-bars are provided, each generator and each feeder circuit being provided with two switches, one for each set of bus-bars, which gives all the flexibility necessary in a power-station of this size. Connected with each of the bus-bars is a ground-detector, voltmeter and power-factor indicator.

Looking at the front of the board, the three generator-panels occupy the left end.

Each panel contains 1 ammeter, 1 power-factor indicator and 1 voltmeter, synchronizing plug, synchronizing lamp, field-switch, field-rheostat and two switch-levers, each of which operates a 3-pole oil-break switch.

Each switch is provided with a time-limit overload-relay, which automatically releases the switch and allows it to open if the current through the switch rises above a certain predetermined value.

An incandescent lamp, immediately over the handle of the switch-lever, lights up when the switch automatically opens, thus attracting the attention of the switchboard attendant.

The station-panel, mounted next to the generator-panels, contains a double set of instruments, one for each set of bus-bars, each set comprising three ammeters, one on each phase, for indicating the current passing, and one Thomson integrating wattmeter for recording the power delivered to each set of bus-bars. A ground-detector for each set of bus-bars is also mounted upon this panel.

Adjoining the station-panel are the five feeder-panels, each containing three ammeters, a recording wattmeter and two switches, whereby each circuit may be connected to either one or both sets of bus-bars.

One feeder-panel is reserved for station use and controls a circuit supplying current to a bank of three 100-kw. oil-cooled Westinghouse transformers, which transform the supply from

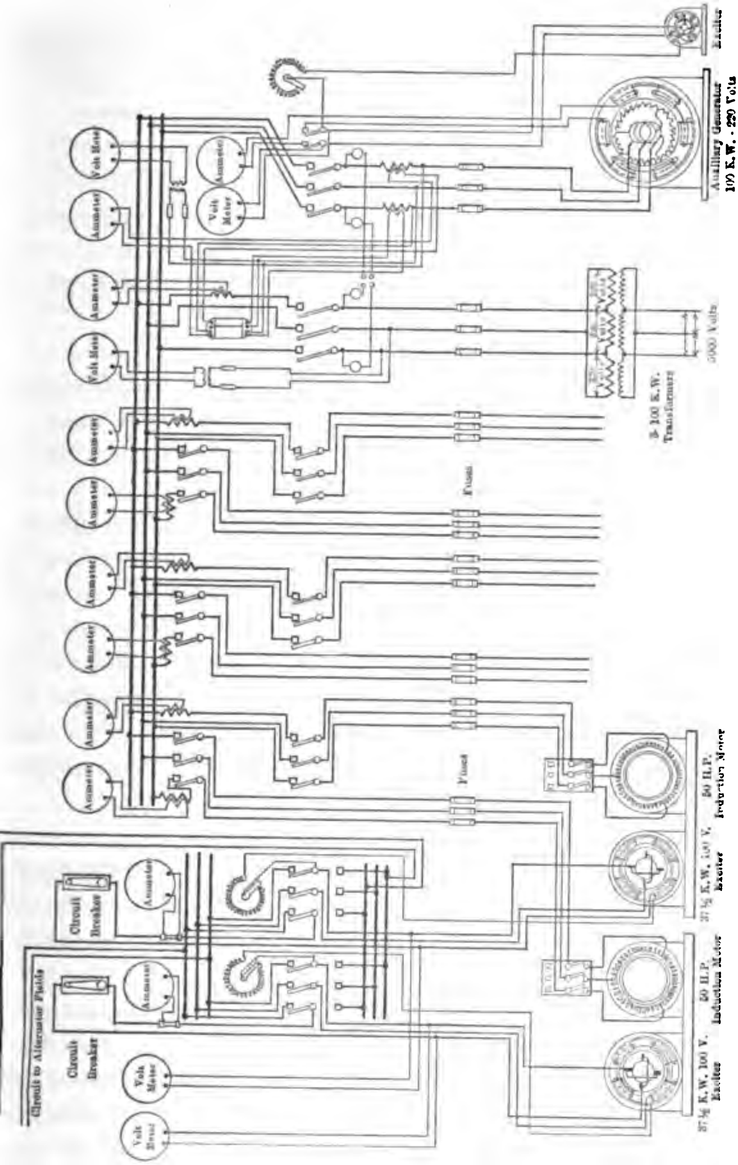


FIG. 11.—WIRING-DIAGRAM OF LOW-TENSION SWITCHBOARD.

,000 volts down to 220 volts. The current at the lower pres-
ure is delivered to the low-tension board supplied by the West-
nghouse Co., containing the apparatus for controlling the va-

rious circuits in the station; the connections are shown in Fig. 11. One panel is provided for carrying the instruments for controlling the two motor-driven exciter sets, and another panel contains the controlling-apparatus for a small engine-driven, 3-phase, 220-volt alternator of 100 kw. capacity. This latter machine is provided for cases of emergency, when it may be necessary to cut off the supply of power to the station. The small set is constantly under steam, and can be immediately started up and made to supply power to motors driving the auxiliary apparatus in the station until the turbine-generators are able to pick it up. With each change of shift this auxiliary set is brought up to speed and excited, so as to insure proper working when required.

A small "Imperial" Rand air-compressor, driven by a 3-h.p. induction motor, supplies air for blowing-out armatures, etc.

A time-clock, operated by keys inserted into locks located in various parts of the station, registers the visits of attendants to the apparatus, such as fan-bearings, etc.

An overhead electric crane is provided in the turbine-room of sufficient capacity to lift the generator-armatures, which are the heaviest single pieces, weighing about 20 tons.

IX. Operation of Plant.

The operation of the plant has been most successful, and considering the many features new to the locality, such as mechanical stokers, steam-turbines and poly-phase electric work at 5,000 volts pressure, it has shown most satisfactory results.

The following log of coal-consumption is given to show the results obtained under ordinary working-conditions, the figures having been taken from the regular weekly station report for seven days, from midnight, Sunday, April 2, 1905, to midnight, Sunday, April 9, 1905.

Coal consumed (Glencoe pea) 548,200 lb.; Ash removed, 86,700 lb. (Percentage of ash, 15.8.) Kw.-hr. generated, 154,840; kw.-hr. distributed, 131,314; pounds of coal per kw.-hr. generated, 3.54; pounds of coal per kw.-hr. distributed, 4.18.

The coal and ash were measured by 20-cu. ft. car-loads, average cars being weighed each day.

A small laboratory for calibrating instruments, making

ınalyses of coal, and running continuous checks on flue-gas, vas built adjacent to the power-station.

The operating staff required in the station is as follows:

1 superintendent,	$170.10 per month.
3 turbine-drivers, 8 hr. each per day, responsible for turbines and condensing-plant, at	$4.86 each per day.
3 oilers, working 8 hr. each per day, oiling on turbines and condensing-plant, at	$4.00 each per day.
3 switchboard-attendants, working 8 hr. each per day, at	$4.00 each per day.
2 head boiler-men, working 12 hr. each per day, at	$4.86 each per day.
2 helpers, looking after coal, ashes, etc., working 12 hr. each per day, at	$4.00 each per day.
2 mechanics, on repairs and maintenance, at	$4.86 each per day.
2 general helpers, clearing up, boiler-cleaning, etc., at	$3.20 each per day.
6 natives, tipping ashes, shoveling coal, etc., at	$1.00 each per day.

South Africa is peculiar in its ideas of dignity of labor. A ıan who, in America, England or on shipboard, is quite willıg to trundle an ash-barrow, scrub a deck or perform other ıenial service, becomes most unwilling to do the same work ı South Africa. He will "boss up" the job—that is, superise natives—but will not do the work himself.

This view is quite natural when the conditions are underood, generations of custom having relegated to the native ertain classes of work which are considered to lie beneath the lane of a white man's calling. Hence the necessity of proiding both white and native labor to perform work which, in merica, would be performed by the white alone.

X. Cost-Keeping.

An accurate account of costs is kept of charges in connection ith the power-station, and the various departments in the mpany purchase power at cost price, nothing being added r capital charges. Table I. shows the style of cost-sheet, in hich each item has an account number (Coal-handling plant)1, Ash-handling 802, etc.), these numbers being a part of the eneral cost-keeping system of the De Beers Co.

The various items are arranged as shown, and all charges r work done in the shops of the company are entered against e item for which the work was done.

The charges for attendance, water, fuel and stores are not ıtered against individual items, but are lumped against groups

TABLE I.—*Cost-Sheet at*

Working Expenses—Central Power-Station, For..................190...

	Workshop Charges.							Attendance.			Water.		Fuel.		Workshop Stores and Sidings.
	Carpenter Shop.	Machine Shop.	Blacksmith Shop.	Boiler Shop.	Electrical Shop.	Painters.	Total.	White Wages.	Native Wages.	Total.	Vaal River.	Dams.	Coal.	Wood.	
801 Coal-handling plant															
802 Ash handling															
803															
804															
805															
806 Feed-pumps															
807 Filters															
808 Economizers															
809 Feed-piping															
810 Furnaces															
811 Stokers															
812 Boilers															
813 Flues															
814 Draught fans															
815 Steam piping															
816 Blow-down piping															
817															
818															
819															
820															
821 Turbines															
822 Oil system															
823 Generators															
824 Exciters															
825 Switchboards															
826 Auxiliary set															
827 Compressor															
828 Crane															
829															
830															
831															
832															
833 Exhaust piping															
834 Condensers															
835 Air-pumps															
836 Circulating-pump															
837 Make-up pumps															
838 Intake															
839															
840															
841															
842 Station lights															
843 Buildings															
844 5,000 volt cables															
845															
846															
Totals															

Kilowatt hours generated in Power-Station........................Cost per unit........................

Kilowatt hours consumed in Power-Station.......................

Kilowatt hours delivered from Power-Station......................Cost per unit........................

(Kilowatt hours received by Company's Works
exclusive of Town Lighting, Trams, etc.) ....Cost per unit....................Adjusted.

*e Power-Plant.**

Distribution of Power to Sub-Stations.

Stables.		Grand Total.		No.	Kilowatt Hours Delivered from C. P. S. to Sub-Stations. Location.	Kilowatt Hours Received from C. P. S. by Sub-Stations. Location.	Cost.
				1	Combined haulage	De Beers (surface)	
				8	Bultfontein }	" (underground)	
				10	Dutoitspan }	Pulsator	
				9	Wesselton	Workshops	
				13	Dutoitspan, No. 2 Machine	Kimberley (surface)	
						" (underground)	
						No. 4 washing machine	
						Bultfontein (Company Work, surface)	
						" (underground)	
						Wesselton (surface)	
						" (underground)	
						" (wash. machine)	
						Dutoitspan (surface)	
						" (underground)	
						" (open mine)	
						" (pan pump)	
						Dutoitspan No. 2 Machine)	
						Kenilworth	
						No. 3 De Beers	
						(Town Lighting & Trams Beaconsfield and Ky.)	
						Total units received	
						Transmission loss	
					Totals	Totals	

$$\frac{\text{Total cost of power generated}}{\text{Total units received}} = \text{........ Cost per unit received.}$$

	Profit	Loss
Balance from Kimberley town lighting		
Balance from Beaconsfield town lighting		
Balance from Alexandersfontein Trams		
Balance from Victoria Tramways		
Net balance to be absorbed		
£		

	Grand Total.
Locomotives	
Power-station office	
Salaries	
Total cost of power generated	
Balance from town lighting, trams, etc	
Adjusted total cost of power	

(* Size of original blank, 16 by 31 in.)

of items, there being five such groups: 1, coal- and ash-handling; 2, steam-generating plant; 3, steam-using plant; 4, condensing-plant; 5, buildings.

The totals are combined, and to this sum are added: Locomotives for bringing supplies to plant and taking men to and from work; clerk, stationery, etc., in power-station office; salaries, including superintendence, and a portion of the general management-charges of the entire company, which gives a grand total of the entire cost of power generated.

Certain portions of the power are sold to the towns of Kimberley and Beaconsfield and to trolley-companies operating in them, the profits from such sales being deducted from the generating-costs, and a new "adjusted cost" thus obtained. This adjusted cost, divided by the units received at the various sub-stations, gives the cost per unit chargeable to the mining operations of the company.

The following data, per kw.-capacity of output of station, is of interest:

	Sq. Ft.
Grate area,	0.158
Boiler heating-surface,	12.00
Superheater surface,	1.167
Economizer surface,	2.15
Total heating-surface,	15.317
Condenser surface,	4.25
Area occupied by steam-raising plant, boilers, economizers, flues, stacks, pumps, etc.,	3.03
Area occupied by turbines, generators, switchboards, exciters, condensers, etc.,	1.8
	Cu. Ft.
Hot-well volume,	0.04
Filtered-water storage,	0.14

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Work of the Testing Department of the Watertown Arsenal, in Its Relation to the Metallurgy of Steel.

BY JAMES E. HOWARD, ENGINEER OF TESTS, WATERTOWN, MASS.

(New York Meeting, February, 1908.)

AT the request of the Council of the Institute, I have the honor to submit the following remarks upon the Program of Tests under which the current work of the Watertown Arsenal Testing Laboratory is carried on, which comprises, among other items, the tests of steel ingot metal and derivative shapes.

The intended scope of the tests may be illustrated by extracts from the descriptive part of the program as submitted by the Laboratory under date of April 17, 1907, and subsequently approved by the Chief of Ordnance, U. S. A.

Under Item 1, Ingot Metal—Open hearth, acid and basic; Bessemer, acid and basic; crucible; fluid compressed and uncompressed—descriptive remarks were made as follows:

"A thorough, fundamental inquiry into the physical properties of steel necessarily begins with the ingot metal. Investigations, having for their object the improvement of steels, should also begin with the ingot. A knowledge of the ingot structure is essential for judging of the subsequent behavior or appearance of the metal. Under ordinary conditions, so little information is obtained from the ingot in individual cases that practically none of importance is acquired. These remarks have particular reference to the state of physical and structural soundness of the steel. Questions of chemical composition, segregation, piping and the grosser cavities have frequently been given attention. Defects of continuity of structure, which manifest themselves in the working of the metal, and at the final stages cause distrust in the finished forging, have generally been neglected.

"The range in physical properties in a given composition of metal, as shown in *Tests of Metals*, 1902 and 1903, is very great. Tests are there found which, when the results are

plotted on stress-strain diagrams, practically cover all parts of the diagram above the curve of primitive strength of the ingot. That is to say, the physical properties admit, and quite easily, of such modifications that strong metal, weaker metal, large elongation and contraction of area may be introduced at will in the steel."

To the official program was attached a diagram illustrating the range in tensile properties of a 0.20-carbon steel, the results being brought together from data in the reports of *Tests of Metals*, in order to show how wide such a range could be. The program went on to say:

"It is desired to emphasize this feature, since it has a bearing on the question of establishing limits prescribed by specifications governing the strength of steel for acceptance of the metal. This wide range in strength does not suggest, in itself, what combination of properties is most suitable for a given piece of work, but the arbitrary character of specifications in general is made apparent by an exhibit of the kind shown in this diagram, especially when the results of tensile tests are taken in conjunction with the results of repeated stresses.

"Broadly stated, each grade of steel, chemically considered, can have its tensile properties materially modified by ordinary methods of treatment in common shop use, some grades admitting of wider variations than others, but each admitting of substantial modifications, all states of the metal being serviceable for some constructive purpose, although it is obscure what particular treatment is best for a specific use of the steel. So far as known, desired physical properties may be imparted to steel in its final stages by heat or mechanical treatment—that is, during processes remote from its initial period in the ingot, but unsoundness of structure seems incorrectable.

"These remarks are intended to show what features are regarded as of peculiar importance, and which are best determined in the period when the metal is in the ingot.

"The chief feature to be taken into consideration at the time the metal is in the ingot state is believed to be that of structural soundness and continuity. Evidence seems to show that structural discontinuity in the ingot is not corrected in the subsequent forging operations. These defects are obscured, but not effaced. If the direction of the stresses, in the subsequent

test, is in the direction of the flow caused by the forging operations, the defects may pass unnoticed. Their presence, however, is made manifest by the application of stresses applied normal to the lines of structural discontinuity. These remarks are extended somewhat at length on account of the grave importance of the subject. The question of 'streaks,' which has occupied attention for the past ten years, is involved in the matters now being discussed. That streaks have their origin in the ingot, and are due to lines of structural unsoundness, is believed to rest on adequate evidence, and therefore a favorable time to judge of the extent and gravity of such defects would seem to be when the metal is in the ingot. Subsequent tests for acceptance, in the forging, from this point of view, should therefore mainly serve to indicate whether the prescribed tensile properties had been imparted to the metal.

"The ingot tests here contemplated are in the direction of establishing the question of structural soundness and continuity, or chiefly in that direction. For general engineering purposes, this feature is of importance. Steel rails, for railway service, may be mentioned as examples in which structural continuity of the metal is important in a high degree.

"Steels made by each of the three processes, open hearth, Bessemer and crucible, should be taken up in the examination of the ingot metal. The composition of the several ingots examined might properly represent ordinary commercial product, and, when practicable to obtain, similar compositions in the open hearth and Bessemer ingots. Fluid compressed and uncompressed ingots should each be examined with reference to their state of physical soundness and continuity of metal.

"In carrying out experiments on ingot metal as well as along other lines of inquiry, the position of the Testing Laboratory should be such as to take advantage of the highest development in the art. That is to say, the material and data collected for the purpose of experimental research should be had from sources where the highest skill now prevails in the art of steel-making. In thus obtaining reliable material, made by steel experts and manufacturers of high reputation, there is assurance that proper material is obtained and also, which is equally important, that the test material represents the quality

of good commercial product, and the tests thereupon may be accepted as indexical of good commercial work of to-day.

"In the collection of material, the steel works data on the material used and furnace conditions should be obtained, so far as possible. Test material in general should be well described in respect to its history."

Under Item 2—Blooms, Billets, Rolled and Hammered Shapes from Ingots—the program reads as follows:

"The examination of steel, beginning with the ingot, should be followed through each subsequent stage. There are several stages gone through which do not represent periods at which the product ordinarily reaches the market and is made use of commercially; but, notwithstanding this feature, a complete knowledge of the properties at each stage becomes of value and interest.

"Rolled and hammered shapes will include finished products of all kinds. Some of this class will represent material reduced directly from the ingot, in ordinary manufacturing operations. Material under this heading will also comprise that which is experimental only, being worked up from some of the metal which had been examined in the ingot. Lack of structural continuity in the ingot should be carefully followed in the blooms and billets made therefrom.

"The working temperatures, reductions in the rolls or under the hammer, and the number of passes in the rolls should be ascertained. The material comprises that which is worked above atmospheric temperatures, at forging heats and other high temperatures. Since the physical properties are so readily modified by work done at different temperatures, the need of information on the conditions of treatment as a part of the test record is readily seen.

"In addition to questions on the influence of temperature on the final properties, there is also the question of interest as to how much or how little work at a given temperature is essential to accomplish the attainable changes in physical properties. That is, to define what amount of work at a given temperature is essential to attain maximum tensile strength and the display of those other features which accompany the tensile test.

"In experimental research many details do not permit of

pre-arrangement, and therefore it will not be undertaken to describe the exact nature of many of the proposed tests, only remarking that efforts will be made to discover new data on the properties of the materials, which last remark summarizes the method of procedure, as a rule, in experimental work."

In the inauguration of the tests the Laboratory has obtained the assistance of Mr. William R. Webster, consulting engineer, on matters pertaining to the metallurgy of steel and mill-practice, and of Prof. Edgar Marburg, of the University of Pennsylvania, on the tests on structural members. These groups of tests comprise two of the principal lines of inquiry of the current program.

Through the efforts of Messrs. Webster and Marburg, a representative body of leading metallurgists and engineers of the country convened in New York in September last for the purpose of discussing the work to be undertaken by the Watertown Arsenal Testing Laboratory, and indicating the specific tests, the results of which should furnish information along the lines of immediate interest and importance. This meeting of September 24 last, through the kindness of the Secretary, was held in the rooms of the Institute. At this meeting, which was presided over by Dr. C. B. Dudley, the morning session was devoted to the discussion of structural members, while the afternoon session was occupied upon matters pertaining to the metallurgy of steel, with particular reference to the examination of ingot-metal and rolled shapes. Two committees were appointed by the Chairman, one on structural shapes and one on metallurgical matters. The composition of the latter committee is as follows:

Watertown Arsenal, Major C. B. Wheeler, Commanding Officer; Mr. James E. Howard, Engineer of Tests, *Ex officio.*
Mr. William R. Webster.
Prof. Edgar Marburg.
Dr. Chas. B. Dudley.
Baldwin Locomotive Works, Mr. S. M. Vauclain.
Cambria Steel Company, Mr. E. F. Kenney.
Maryland Steel Company, Mr. F. W. Wood.
Standard Steel Works, Mr. A. A. Stevenson.

In order that these tests may be carried out in a broad and comprehensive manner, an earnest request is made that the members of the American Institute of Mining Engineers participate in the discussion of the work of the Laboratory and indicate the specific tests which, in the judgment of the members, will contribute towards advancing the many questions which so broad a matter as the examination of ingots and rolled shapes involves.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Tar-Sands of the Athabasca River, Canada.

BY ROBERT BELL, M.D., LL.D., D.Sc., F.R.S., OTTAWA, CAN.

(Toronto Meeting, July, 1907.)

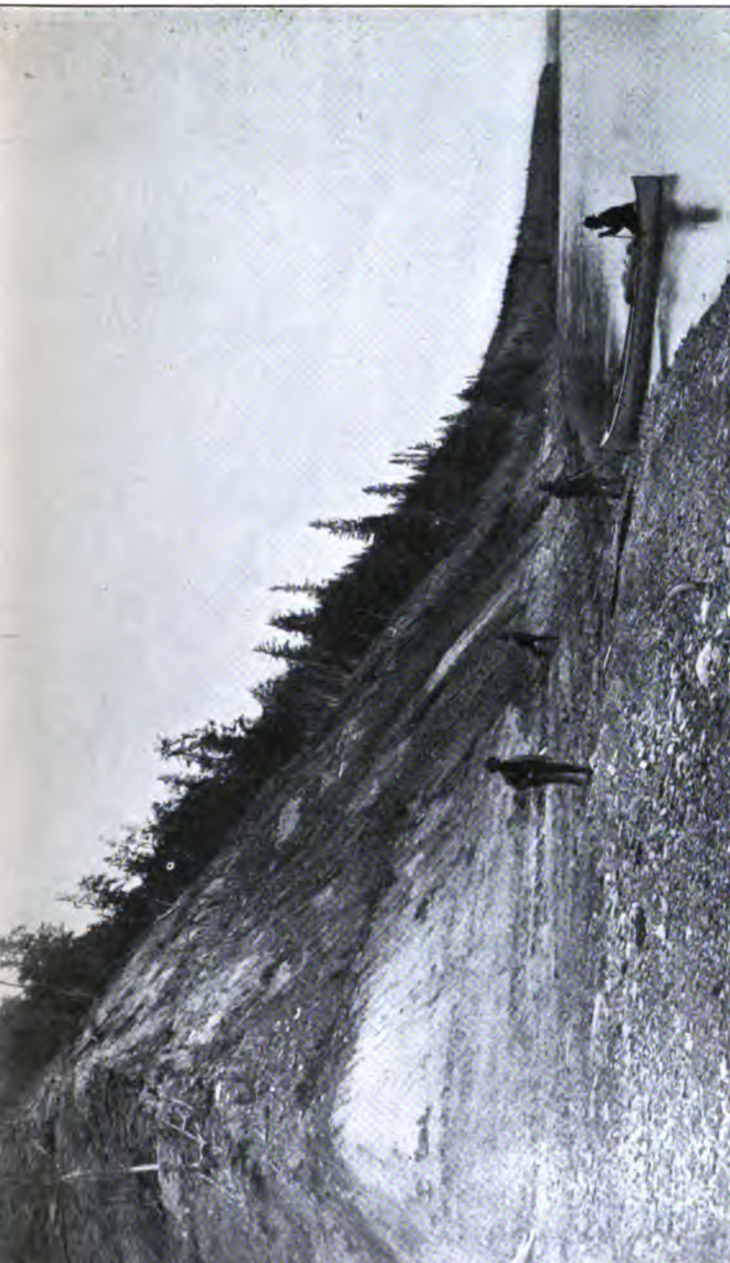
THE "Tar-Sands" is the name which has been given to the extensive horizontal deposit of fine Cretaceous sand, blackened by tarry petroleum, which forms the banks of the last or lowest 130 miles of the Athabasca river before it terminates in Athabasca lake. The Cretaceous strata, to which these sands belong, extend northwesterly from Dakota all the way to this lake and for 500 miles beyond it.

The Athabasca river forms the uppermost section of the Athabasca-Mackenzie, one of the great rivers of the world. It rises on the Pacific side of the Rocky mountains, westward of Edmonton, and flows north of east to a point called Athabasca Landing, 100 miles north of Edmonton, where it turns northward and runs about 280 miles before it falls into the west end of Athabasca lake. The section of this river-system which discharges the lake just named into Great Slave lake, is called Slave river, and below the latter lake it becomes the Mackenzie river.

Along the section of 280 miles of the Athabasca river above mentioned, the Cretaceous strata consist of bluish-gray and drab-gray marls, on top, from Athabasca Landing to Drowned rapid, 110 miles down stream; then heavily bedded gray sandstones, 225 ft. in greatest thickness, underlying these, form the banks for about 40 miles further. The strata appear to be horizontal, but they really dip very slightly to the southward. At Drowned rapid, we see the first of the tar-sands resting on almost horizontal beds of bluish-gray limestone of Devonian age. In some places the limestone is associated with shaly or marly bands. Notwithstanding the great hiatus between the two series, the horizontal tar-sands lie conformably upon the almost level upper beds of the limestone wherever the two formations are seen together, all along the river, throughout a

distance of more than 100 miles. Slight local undulations occur in the limestone, but its general attitude is nearly horizontal. Its surface shows little erosion. We have here a rather puzzling phenomenon. How could an extensive horizontal surface of consolidated limestone retain a fresh and only locally eroded surface and then receive directly upon it a thick deposit of sand, also in horizontal beds and holding numerous seams of lignite? The erosions, occasionally seen, consist of shallow smooth-surfaced depressions scooped out of the uppermost beds.

Fort McMurray, 132 miles in a straight line upwards from the mouth of the Athabasca, at The Forks or junction of the Clearwater river from the east, is a well-known land-mark, from which distances up or down the main river are measured. In descending the Athabasca, the tar-sands begin to appear in the banks at Drowned rapid, as already stated, about 30 miles above Fort McMurray, and the Devonian limestone is seen for the first time at Crooked rapid, at the level of the water, 20 miles above the same point. The limestone everywhere shows itself only at the edges of the river, and would be represented by a mere line on the geological plan. The fossils indicate that it should be correlated with the higher portion, and the Devonian system probably has a great thickness in this region. The Cretaceous rocks, all the way from Athabasca Landing to the mouth of the river, also appear to belong to the higher beds of this series. Although the tar-sands are seen in the banks of the river for a distance of about 110 miles, they are not known to extend far inland to the east; while on the west side, at a considerable distance from the river, they are probably overlaid by argillaceous bands the same as to the south. In the 30 miles above Fort McMurray, the tar-sands show a thickness of from 40 to 60 ft. in the banks, while for some miles below the fort they form the entire east bank, which rises from the edge of the water to a height, in some places, of about 200 ft. It is estimated that the greatest thickness of these sands is about 225 ft. From a point a few miles below Fort McMurray, the height of the east bank diminishes gradually in descending the river all the way to the delta, which is only slightly raised above the level of the water, and the blackened sand is visible nearly the whole distance, wherever the banks are not covered with trees. Figs. 1 and 2



Dr. R. Bell, Photo.

Fig. 1.—Tar-Sands, East Bank of the Athabasca River, 5 Miles Below Fort McMurray. (Looking South.)

Dr. R. Bell, Photo.

[4]

are photographic views of the east bank of the Athabasca river, 5 and 6 miles below Fort McMurray.

The tar in these sands has, no doubt, resulted from the evaporation and oxidation of the petroleum which passed upward through them during a considerable period of time. Along this part of the river the tarry sand either forms the surface of the country at the top of the banks or is overlaid only by till and drift sand and gravel, which to the southward contain no tar, although these deposits do hold rolled balls of mixed tar and stones and a few small patches of tar in some places further down the stream. It is therefore probable that, for a long time previous to the drift period, great quantities of petroleum escaped to the surface and were lost, or that much of the saturated sand was swept away before what now remains was covered by the drift-deposits. But to the south and west the tar-sands pass under the clayey marls, which would prevent the free escape of the oil to the surface.

The petroleum which saturated this Cretaceous sand-formation evidently came up from the Devonian limestones on which it rests, and probably from their deeper portions, as the limited exposures seen immediately below the tar-sands contain very little bituminous matter. In the cracks and joint-planes of these limestones, however, hardened tar or pitch may occasionally be seen, showing that petroleum has passed upwards through them at a remote period. The united thickness of the limestones and shales exposed in the upper beds along the river, from their first appearance, 20 miles above Fort McMurray, to the most northern outcrop, does not probably amount to 100 ft. The upper surface of the limestone, therefore, appears to slope northward with nearly the same grade as the river, which would average about 3 ft. to the mile or a total fall of 396 ft. As the Cretaceous rocks of the upper half of the distance to Athabasca Landing dip gently to the southward, a low E–W. anticlinal axis would appear to cross the river about Crooked rapid, or nearly midway between the lake and Athabasca Landing, always presuming that the Devonian limestone under the upper half of the distance continues to be conformable to the overlying sandstone.

In some places the Cretaceous sand-formation is not blackened by the tar, showing that the former escape of the pe-

troleum from the underlying limestones was not universal, so that possibly, at well-selected points in such unstained areas of the sand, there may be a better chance than elsewhere of finding liquid petroleum by boring to a considerable depth into the limestone.

The bitumen or maltha is, however, here present in far the greater portion of the Cretaceous sand-formation, which it supersaturates, giving it a coaly black color, and rendering invisible the numerous seams of lignite which it contains. Under the hot summer sun, the tar-sand melts at the surface and flows down the steep naked banks, rolling over and incorporating dry sand and stones, which have fallen from the drift above it; and breaking away in balls and rolls, it accumulates along the foot of the bank. The sand is fine-grained, and at cool temperatures the mass may be chopped out in lumps without any visible effect on the edge of the axe. When piled upon a wood fire, the lumps burn like cannel coal for some time and then collapse into sand.

In going down the Athabasca river, the tar-bearing sands are first seen, as already mentioned, at Drowned rapid, 30 miles above Fort McMurray. From this rapid it is exposed, with some intervals of concealment, all along the river to a point 9 miles below the junction of the Calumet from the west, a distance of 90 miles, but it probably continues under the surface-deposits nearly to the head of the delta of the Athabasca, or a total distance northward of at least 100 miles. The breadth of the country westward of the river which is underlaid by the tar-sands is uncertain, but if it should not exceed 30 miles, a low estimate, this tar-soaked formation would have an area of 3,000 sq. miles on the west side of the Athabasca. It is seen also almost continuously along the east side of the river from Drowned rapid nearly as far as on the west side, and no doubt also continues under the low country approaching the delta. It does not, however, appear to extend as far east as it does west from the river. In ascending the Clearwater river, which joins the Athabasca from the east at Fort McMurray, large masses of the thickened sandy tar, similar to those which roll down the steep banks of the Athabasca, were found in the bed of the stream at 11, 13 and 17 miles from its mouth, and these

probably indicate the existence of the tar-sands concealed under the moss and trees which cover the banks.

At Drowned rapid the tar-bearing formation is only 10 ft. in thickness, but it increases steadily until it has attained 200 ft. a few miles below Fort McMurray, and its maximum is apparently about 225 ft., although it may be greater under the low ground of the northern part of its area. If its average depth should be only about 100 ft., the total quantity would still be enormous.

The tar-sands and liquid tar of the Athabasca have been known to the fur-traders of the Mackenzie River district from the earliest times. They were mentioned by the first travelers that wrote about the country, particularly by Sir John Richardson, who described this part of the Athabasca in 1823. They were noticed along with other occurrences of petroleum in the Northwest Territories in a paper which I published in 1881,[1] On the Occurrence of Petroleum in the Northwest Territories with Notes on New Localities. The geological relations of these deposits, their distribution, volume, origin of the petroleum, etc., are fully described in my accounts of this region.[2] Additional information is given in the report of Mr. R. G. McConnell, ten years later,[3] on A Portion of the District of Athabasca. Owing to the absence of railways in the district, but little effort has yet been made to bore for liquid petroleum under the surface.

In 1897 and 1898 a bore-hole was sunk, at the expense of the Geological Survey,[4] on the west side of the river at Pelican rapid, 80 miles in a straight line above Fort McMurray. At a depth of 820 ft. a great flow of gas at high pressure was encountered, and this effectually prevented further boring. The gas has continued to escape with a roaring noise, through a 4-in. pipe, during the nine years which have elapsed since it was first struck. For some years, the noise was so great that it could be heard at a distance of two miles or more, especially

[1] *Proceedings of the Canadian Institute*, Series III, vol. i., pp. 225–230 (1879–83).

[2] *Report of Progress of the Geological Survey of Canada*, 1882–83–84, Part C C; also *Summary Report for* 1889, pp. 103 to 110.

[3] *Annual Report of the Geological Survey of Canada*, vol. v., part I., report D (1892).

[4] *Summary Report of the Geological Survey of Canada for* 1897, pp. 18 to 25; 1898, pp. 28, 32 to 34.

in the winter. After nine years the pressure appears to be lessening, although this may be due to some obstructions in or below the casing. When the gas was originally encountered a little thick, dark petroleum was said to have been blown out of the bore-hole.

The black and viscid tar which saturates the Cretaceous sands so abundantly in the large area above described, has no doubt resulted, as above stated, from the partial evaporation and the oxidation of a more fluid form of petroleum that entered the formation from below. Its original source has probably been in the deeper strata of the Corniferous (Devonian) limestone underlying the sands. It is possible that it came from a formation or formations below the Corniferous; but the tar is so generally diffused in the sand that it is more probable it came from the formation immediately below it, because the deeper the oil-producing strata the fewer points of escape it would have by the time it reached the Cretaceous sand. The numerous exposures of Corniferous limestone seen under the tar-sands showed little evidence of containing bitumen, except as black incrustations in joint-planes, cracks and vugs, which were observed in some places.

The geographical area of the tar-sands, the thickness of the deposit, as well as the large proportion of the contained tar, all indicate an enormous quantity at the original source of supply. The saturation of the sand is not uniform throughout. On the contrary, in a few localities no oil at all appears to be present, while in others the sand shows different shades of brown and black, according to the amount of petroleum it has received.

In any petroleum-bearing region the oil is believed to be held under impervious strata in low anticlinals or domes until the accumulation is punctured by an artificial boring. In the region in question, several local anticlinals were observed in the beds of Devonian limestone and marl immediately under the tar-sands. Any accumulations of petroleum which may still exist at greater or less depths in the limestone, or in formations underlying it, probably remain in such anticlinals and domes, the arrangement of which may be quite independent of that of the overlying unconformable tar-sands. The area of the deep-seated petroleum-bearing rocks being large and the conditions varied, it may be reasonably supposed that all the oil has not yet escaped.

ut that considerable quantities may still be imprisoned at
arious depths in some parts of the field.

The complete or partial absence of tar in the sand at any par-
icular place does not necessarily indicate that a certain share
f the petroleum, which had elsewhere escaped upwards into the
and, still remains below such a locality. Its absence may be
ue to its having been carried past by a slight ascending grade
long the axis of an anticlinal, or owing to the spot being situ-
ted over a basin or a synclinal form in the strata, or to some
ther cause not readily explainable.

If the main or general anticlinal of the whole district, as in-
icated above, runs approximately E–W., which appears prob-
ble, any subordinate anticlinals may be expected to have a
omewhat similar course. The evidences of very profuse out-
ouring of petroleum towards the surface in former times may
ot be the best indication of its present existence at consider-
ble depths, since it may have escaped so freely as to have left
ut little behind. A careful geological survey of a wide enough
rea should be made, and the exact direction and amount of the
ip of the Devonian rocks at numerous spots should be marked
ith precision at each particular locality upon a large-scale map,
hich should also show the relative proportions of the tar in
e overlying sand-formation, and all other facts that might aid
determining the most promising sites at which to locate trial
orings. This being a new and practically untried oil-territory,
may be found that some peculiar conditions exist, a knowl-
dge of which is necessary to success; so that, after having
ken all such precautions as those above mentioned, numerous
xperiments may be necessary at first to discover the mode of
ccurrence of the oil and the best method of reaching it by
oring.

But even if it should be proved that no liquid petroleum was
be found by sinking wells in this region, the bitumen, tar,
maltha of the sand itself exists in such enormous quantities
at it will, no doubt, be utilized in the near future. On the
sumption that the saturation of the fine sand by the tar ex-
nds from the bottom to the top of the formation over the
hole area in which this sand forms the surface, and after
aking allowance for the unimpregnated spots, the quantity
this material in the Athabasca district would amount to

from 50 to 100 cubic miles, or many billions of tons, and it would be practically inexhaustible. Professor H. V. Winchell, in discussing this point with me after the reading of this paper, thought it was quite possible that the tar was more concentrated towards the surface of the country and the face of the banks than throughout the mass; but the saturation appears to have taken place before the present banks were formed. I am not aware of any other place in the world where there is such an immense surface-showing from the uprising of petroleum. Owing to the evaporation of the lighter portions of the original oil, its composition cannot now be known, and therefore the total quantity of such petroleum, at present represented by the bitumen in the tar-sands, cannot be estimated. The portions of the formation which have been removed by denudation would greatly increase the amount.

Although little or no bitumen is present at a few localities, and in others there has been a concentration by the draining-out of the tar from the mass, still the coal-black sands which form the great bulk of the formation appear to have a fairly uniform composition. An average fresh sample of this material, collected by me, having a specific gravity of 2.040, was analyzed by Dr. G. C. Hoffmann, late chemist to the Geological Survey, who found it to contain 12.42 of bitumen, 5.85 of mechanically included water, and 81.73 per cent. of very fine siliceous sand. At a temperature of 50° F. it was quite firm, barely, if at all, yielding to pressure, and did not soil the hand; at 70° F. it gave somewhat to the touch, and was slightly sticky; at 100° F. it became quite soft and eminently soiled the fingers.[5] Lieut. Cochrane, chemical instructor at the Royal Military College, Kingston, and Mr. Isaac Waterman, petroleum refiner of London, Ontario, each found about 15 per cent. of bitumen in average samples of the tar-sand which were submitted to them.

The percentage of bitumen which may be found in samples of the tar-sands depends largely on their selection. The melting and flowing-out of the supersaturating tar during the summer produces a much richer variety than the average. Dr. Hoffmann found that a specimen of this kind had a specific gravity of only 1.023, or half that of the sample he analyzed,

[5] *Report of Progress of the Geological Survey of Canada*, 1880–81–82, part H, pp. 3 to 5.

which was no doubt due to the much smaller percentage of sand which it contained.

The heat required for the treatment of the tar-sand may be obtained from this material itself by burning it in lumps on a grate made of corrugated iron, thickly pierced with holes, similar to the grates used for burning very damp sawdust at many Canadian mills, with an additional contrivance for removing the sand, which may be used for making the finest glass. The oils may be extracted by one of the two or three processes which seem to be available, after experiments have determined which of them is the best. The late Dr. T. Sterry Hunt suggested that the lighter oils first obtained by distilling the tar-sand may be used to dissolve out the oil from a fresh portion of the raw material, while the subsequent heavier portion that came over constitutes a valuable lubricating oil. As the fuel and material treated cost nothing but the handling, this may prove a cheap method of extraction.

Dr. Hoffmann found that 70 per cent. of the bitumen contained in the sand can be extracted in a fluid state by boiling it in water. The extracted oil rises rapidly to the surface and may be drawn off. By either of these methods, the great bulk, say 90 per cent., of the crude material may be rejected, thus reducing very much the labor required for distilling and refining the valuable portion, which will then be confined to the bitumen that separates in a fluid state. The pools of pure tar and the pitchy deposits, formed by the natural process of concentration already described, may be found to occur in sufficient quantities to be utilized in the manufacture of refined oils.

Different experiments made with the tar-sands show that, while they yield some good illuminating fluid, their principal value consists in the large proportion of fine lubricating oil which they afford. This oil was found to remain liquid at the cold winter temperatures of the Canadian prairie provinces, and therefore it is very suitable for car-wheels and machinery working in the open air in these or other cold regions.

The high banks of the Athabasca river and its branches in the tar-sand area offer great facilities for excavating this material; and as it occurs in such unlimited quantities, and can be taken out in lumps suitable for burning at a trifling cost, there

will be no restriction on its free consumption, one portion of the raw material being used to produce oil from another. When this part of the country becomes inhabited, and towns and villages spring up in various directions, the tar-sands may be used for roofing and paving, and also for the manufacture of illuminating gas, as well as oil.

From what has been stated above, it is reasonable to expect that this immense deposit of tar-sand in the Athabasca district may be destined to prove, at some time, of great economic importance. The material, just as it occurs, with little or no artificial treatment, is ready to be utilized as asphalt for paving, roofing, electric insulation and other purposes. The natural intimate combination of the fine sand and bitumen imparts to it a quality which no artificial mixture of similar components could be expected to possess. Some cheap means may be found for its transportation to towns and cities where it will meet with a ready market.

Dr. Hoffmann found that the sand, which forms about 80 per cent. of the deposit, consists of grains of pure vitreous quartz, suitable for the manufacture of the finest white glass, so that we have here both the fuel and the silica for glass-making. The Geological Survey has proved that common salt exists abundantly in a dry state and also as brine in many places all along Salt river, a branch of Slave river, which is the next section of the Mackenzie below the Athabasca; and also at a place called La Saline, on the latter, where the brine flows over a wide, smooth surface of the tar-sand, leaving conspicuous deposits of salt in the neighborhood. No doubt great quantities of brine could be obtained by boring into the Devonian strata, from which the brine proceeds, so that an abundant supply is available for conversion into sodium carbonate, to use with this excellent form of white silica for the manufacture of glass, for which the tar-sands would furnish cheap fuel at any locality where the works might be located. It is probable that natural gas could also be found by boring.

In regard to a market for the oils which may be produced from the tar-sands or by sinking wells, it may not be a long time before this region is reached by railway from the south. There is already a considerable demand for illuminating and lubricating oils in the prairie provinces and British Columbia.

If the output should become very large, the refined oil could be piped to Fort Smith on Slave river, and thence sent on tank steamers, by way of Mackenzie river, to the northern ocean, which is open from the mouth of this great stream to the Pacific. Or it might be carried by steamers to the waters east of Athabasca lake, and thence piped to Churchill harbor on Hudson bay.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Ore-Deposits of the Eastern Gold-Belt of North Carolina.

BY W. O. CROSBY, BOSTON, MASS.

(Toronto Meeting, July, 1907.)

INTRODUCTION.

THE crystalline belt of the Atlantic Seaboard, south of New York, attains its maximum breadth of 220 miles on the northern border of North Carolina; and in this State it is most widely characterized by the occurrence of gold in workable deposits. Half a dozen auriferous belts have been recognized by Nitze and Hanna.[1] These are, in the main, coincident in position and trend with the NE.–SW. zones of metamorphic slates and schists, which, more than any other feature, give character to the geological map of North Carolina. The central gold-belts, accompanying the main zone of slates and associated igneous rocks, are much the more important and persistent, and may be regarded as continuous northward across Virginia and southward into South Carolina. The eastern belt, on the other hand, is the shortest and, economically, one of the least important. Its extreme length does not exceed 25 miles, the narrow band of slaty rocks to which it belongs passing, both NE. and SW., beneath the coastal-plain formations. But, although limited in area and production, this belt is, perhaps, comparable with the central belts or any part of the seaboard crystallines in the variety of conditions under which the gold occurs. It lies chiefly in the NE. part of Franklin county and the NW. part of Nash county, on the watershed of Fishing creek and other tributaries of Tar river. The elevation is between 400 and 500 ft.; and the Tertiary peneplain has here an exceptionally perfect development, the reliefs separating the slightly incised stream-courses consisting of broad, flat-topped peneplain remnants, bounded by gentle lateral slopes.

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[1] *North Carolina Geological Survey, Bulletin* No. 3, p. 15 (1896).

General Geology.

The eastern gold-belt is separated from the central gold-bel by the granitic rocks of the Raleigh, Louisburg and Warre ton area; and these plutonic rocks are clearly younger tha and intrusive in, the associated metamorphic sediments. I traveling east from Louisburg or SE. from Warrenton to th mining district, it is evident that we pass from a complex granitic and gneissic rocks and various schists to an area prevailing quartzites and siliceous slates, which are, howeve freely intersected by the plutonics. Presumably, the sed mentary rocks are wholly of early Paleozoic age; and ce tainly their relations to the igneous rocks, so far as observe are essentially identical throughout the district. The gener line of strike of the sedimentary formations, as previously ind cated, is NE.–SW.; and the prevailing dip is SE. at hig angles. No effusive rocks, either acid or basic, have been o served in this district.

Almost universally, the rocks, of whatever kind, includin even the hardest and most siliceous quartzite, are deeply rotte to normal saprolites; and both lithologic and structural fea ures are thereby greatly obscured. Furthermore, the uplan or peneplain surface is, very generally, overspread by a mant of fine quartz sand. In part this sand appears to be simply th saprolite phase of the quartzite; but elsewhere it is horizo tally stratified and includes, at least basally, layers of quar gravel; and it seems then to require correlation with th Columbian formation.

Genetic and Structural Relations of the Gold-Bearing Formations.

Sedimentary and Plutonic Rocks.—First, in order of age, com the sedimentary rocks, consisting chiefly of normal quartzit grading through siliceous slates into metamorphic clay slat or phyllites. Intersecting these terranes in a highly irregul manner and often transversely is the complex of plutonic rock among which diorite, normal granite and pegmatite are esp cially prominent.

The diorite is believed to be here, as in so many other pl tonic regions, an earlier, peripheral, basic phase of the sam

body of magma which has yielded the granite; and it is clearly cut by dike-like masses of granite. Both the diorite and the granite exhibit marked variations in texture and composition. They are frequently gneissic; and a sheared and chloritized part of the diorite is the chloritic schist of other writers.

The pegmatite, on the other hand, is clearly a later phase of the granitic magma, and forms irregular dikes in all the other rocks of the complex, both igneous and sedimentary. So far as noted, it is of highly acid composition, consisting chiefly of megacrystalline quartz, acid feldspars, and muscovite.

Veins.—In part, the pegmatite is highly quartzose, and shows an unmistakable tendency to grade into quartz-veins, which are the feature of the complex of most particular interest, so far as the occurrence of gold is concerned. This tendency, and the occasional occurrence of coarsely crystalline muscovite, identical with that of the pegmatite, in otherwise normal auriferous quartz-veins, leaves no room to doubt the genetic relation of the pegmatite-dikes to some, at least, of the quartz-veins, or that the gradation is a fact.

Large areas of the complex of sedimentary and plutonic rocks are traversed by an irregular network of quartz-veins, varying in width from a line to 50 ft. or more, but mainly rather narrow, and, individually, highly variable in size and trend. They are, without exception, massive and glassy; and bands, combs, vugs, or other indications of crustification or of endogenous origin are conspicuous by their absence, as are also the selvage-phenomena of normal fissure-veins. The veins have not, as a rule, been worked below the oxidized zone, although this is shallow; but indications of sulphides below the water-level are very meager and often wholly wanting. Aside from the oxidation of the scanty sulphides, the quartz-veins have, in general, survived the rotting of the inclosing formations, and are now traceable, *in situ* and essentially intact, through the residuary detritus or saprolite.

In the central gold-belts of North Carolina, I long since recognized two essentially distinct types of auriferous veins: (1) Massive quartz-veins of varying and often considerable size; devoid of definite selvage, combs and vugs; relatively, and often absolutely, barren of sulphides; and the average gold-tenor low to very low, but highly irregular or pockety, the

gold being free, mainly coarse and nuggety, and thus especially favorable for the enrichment of placers. (2) Relatively narrow quartz-sulphide veins, with the normal structural features of true fissure-veins; and relatively high and even gold-values, the gold being rarely coarse and only to a limited extent free.

The veins of the first class are believed to be, in general, the older; in part, approximately contemporaneous with the granitic rocks; and hence to have been formed under essentially plutonic conditions by so-called magmatic waters, and to admit of correlation, to some extent, as the end-term of the pegmatites; while the veins of the second class are the product of the more normal circulation of the ground-water at less than plutonic depths, and represent the leaching of the upper and less metamorphic zones of the earth's crust by waters largely or chiefly of meteoric origin.

The veins of the second type form the basis, now and then, of continuously profitable mining operations; but those of the first type are rarely payable except locally and transiently, where a pocket or bonanza is encountered. These are the "specimen" veins, which are most profitable to man where they have been extensively mined by the slow processes of erosion and the product concentrated in placer-deposits. Again, having been formed under approximately plutonic conditions, and not being in any large degree dependent upon sulphides for their values, the veins of the first type are not, to any important extent, subject to secondary enrichment by downward leaching. In other words, their marked variations of value are primary and do not, as in the sulphide veins, admit of close correlation with depth, both the coarseness of the gold and its uneven distribution being consonant with a quasi-plutonic origin, which has allowed the principle of segregation to accomplish its most perfect work, bunching the gold in pockets within the veins, and in nuggets within the pockets.

Obviously, the veins of the eastern gold-belt belong to the first or non-sulphide type; and in this fact we find the key to the history of gold-mining in this district. Also, it may be noted here that the best values are found, as a rule, in the narrower veins, the wider ones being of little or no economic interest.

Impregnations.—The immediate country-rock, be it granite, diorite or quartzite, of the quartz-veins and veinlets is often slightly impregnated with gold; but it is doubtful if the degree of impregnation is ever sufficient to make the undecomposed hard rock a practical ore. With the saprolite, however, the case is somewhat different, since it is easily mined and requires no crushing. The mineralized or impregnated granite saprolite, known locally as the "white belt," usually carries the best values. We are considering here a type of deposit—metasomatic impregnation and replacement—which elsewhere in the southern Appalachian region has proved of exceptional importance from a mining point of view. But in this eastern gold-belt it is, even when reduced to the condition of saprolite, of little economic interest, the values being, in general, still too low to justify metallurgical treatment, and the proportion of coarse gold too low to permit a large saving by placer methods. In comparison with the veins, the impregnations are noteworthy for the finely divided condition of the main part of the gold, and for its relatively even distribution. As in the veins, however, sulphides are meager or wholly wanting. In brief, the impregnations partake of the character of the veins which they border, save that the gold is prevailingly fine instead of coarse, and hence unfavorable for the enrichment of placers.

Placers.—Long continued and extensive erosion, resulting in the peneplanation of this region, set free a notable amount of the coarse gold of the quartz-veins and effected its concentration in residuary placers adjacent to the outcrops of the veins from which it was derived. Subsequently, during the Columbian submergence, this residuary gold was still further concentrated, as a marine placer, in the basal layers of the Columbian gravels. Finally, during the erosion of the gravels and the trenching of the underlying peneplain by the modern valleys, the gold again became a residuary deposit; but in large part, also, it was carried down the slopes and experienced a further concentration in the gravels of the stream-beds. Thus, for the surficial, as for the bed-rock formations, we may recognize two principal types of auriferous deposits: (1) residuary and marine placers, representing a primary, vertical concentration in a plane, during the development of the peneplain; and (2) stream placers, repre-

senting a secondary, horizontal concentration in a line, during the trenching of the peneplain.

The bed-rock deposits—veins and impregnations—are, as we have seen, of little economic interest, except locally for the saprolite phase; but where nature has mined these formations by cubic miles and concentrated the gold in the ratio of thousands into one the results may be very interesting, although the deposits are quickly exhausted and do not afford a basis for long-lived mining.

Mining Notes.

My observations in the eastern gold-belt were chiefly confined to three properties: but these appear to illustrate satisfactorily the normal range of conditions for the district.

Alston Mine.—This property is a part of the plantation of Edward Alston, in Warren county, about 16 miles SE. of Warrenton, and on the NW. margin of the gold-belt. Gold was first discovered here in 1847 through the finding of a nugget in the road by one of Mr. Alston's slaves. The situation is a low knoll of saprolite in which may be readily recognized, in order of age, quartzite (sometimes micaceous and garnetiferous), diorite (fine, dark and chloritic), granite (fine, white and micaceous), dikes of pegmatite, and a plexus of quartz-veins. The superficial, residuary deposit or placer has been worked over an area of an acre or more, yielding a considerable amount of coarse gold. Several of the quartz-veins, prospected to the water-level (from 25 to 30 ft.), have also yielded good values; but they are much too small to admit of profitable mining. The fine, impregnating gold is chiefly confined to the vicinity of the quartz-veinlets in a band (dike) of granite saprolite from 20 to 30 ft. wide, forming the "white belt" of this property. In the pan, this impregnating-gold appears as numerous, very minute colors of remarkably uniform size, a condition highly characteristic of this type of deposit and making impossible any large recovery by placer methods.

Sturgess (Portis) Mine.—This mine, the best known and most productive of the eastern gold-belt, is situated near Ransom's Bridge in the NE. corner of Franklin county, at an elevation of about 100 ft. above Shocco creek. The extent of the workings and the variety of deposits which they exhibit make this

property exceptionally favorable for the study of the geologic relations of gold in this district.

The predominant bed-rock formation is the diorite, which is, at most points, thoroughly rotted, yielding, superficially, a deep red soil. Cutting through the diorite saprolite are occasional dikes of fine-grained granite saprolite (white belts). One of these is only from 4 to 5 ft. wide, while another is more than 70 ft.

Both the diorite and the granite are traversed by a network of very irregular quartz-veins, of all sizes up to 2 ft. thick. They are said to be generally auriferous, with pockets running thousands of dollars to the ton, the small veins being relatively the richest. The granite saprolite or white belt also carries appreciable, and, in part, workable values, although the minute subdivision of much of the gold prevents a high recovery.

As usual in the eastern gold-belt, the surficial deposits have been most productive. These include: 1, a considerable area of Columbian gravel, the basal layer of which, resting unconformably upon the diorite and granite saprolites, contains workable values; 2, a still larger area of residuary placer, where the Columbian gravel has been removed by erosion and the gold left directly upon the surface of the underlying saprolite; and 3, the stream gravels in the bed of a minor water-course or "branch," the valley of which trenches the saprolite.

Thus we may recognize here, in obvious genetic relation, five available sources of gold; two original or bed-rock sources—the quartz-veins and the accompanying impregnations of the granite-saprolite or white belt; and three secondary or placer sources—marine, residuary and stream.

The Columbian gravel is still largely intact; but the residuary and stream deposits have been worked to the verge of exhaustion; and to these may be credited a large part of the total product. In part, also, the quartz-veins and white belts have been worked to depths of from 20 to 30 ft., the saprolite being washed, and the quartz trammed to a 20-stamp mill and crushed. The chief handicap to the operations has always been the lack of water, which can be had in quantity or under pressure only by pumping. Were a gravity supply available, hydraulicking of the entire property down to the "branch,"

followed by the milling of the quartz thus mined, and the subsequent cleaning up of the "branch" with a dredge, would, doubtless, yield interesting results.

North Carolina Placer Mine.—The property of the North Carolina Dredging Co. is on the same "branch" which traverses the Sturgess mine, and immediately below the latter. The valley-floor is here several hundred feet wide, with a very low gradient; and the conditions are in every way favorable to the operation of a dredge. A low dam has sufficed to create the necessary pond for a Robinson chain-bucket dredge with a daily capacity of 1,000 cu. yd., working 14 ft. deep. The "pay" streak is a layer of clean gravel, from 6 in. to 3 ft. thick, on bed-rock, with a layer of tough clay over it. Some gold is found in the silty overburden; but it is mainly in the gravel; and the values are fairly even across the valley, although greatest near the middle. The gold is mainly fine to very fine, or such as might have been transported by this feeble stream during a recent period of elevation, when it was flowing on bed-rock.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Corrosion of Water-Jackets of Copper Blast-Furnaces.

BY GEORGE B. LEE, DOUGLAS, ARIZ.

(Toronto Meeting, July, 1907.)

DURING the two years in which the new reduction-works of :he Copper Queen Consolidated Mining Co. have been in operation at Douglas, Ariz., there has developed a remarkable condition in regard to the corrosive action of the water used to :ool the jackets of the blast-furnaces.

Were it not for the many contradictory features, it might pass as one of the unavoidable troubles due to the composition of the water. This water, obtained from wells 600 ft. deep, is ilso used in the steam-boilers, and its composition, as shown by he following analysis, does not indicate the presence of any ngredient which would explain the corrosion:

	Grains Per U. S. Gal.
Silica,	0.861
Iron oxide and alumina,	0.223
Calcium carbonate,	0.261
Calcium sulphate,	....
Magnesium carbonate,	....
Sodium and potassium sulphates,	14.850
Sodium and potassium chlorides,	9.732
Sodium and potassium carbonate,	6.482
	32.409

The jackets are made of inner plates 0.5 in. thick and an outer late $\frac{3}{8}$ in. thick, with $\frac{3}{8}$-in. stiffeners between the inner and uter plates. In from 10 to 12 months the inner plates have een reduced by corrosion to a thickness of from $\frac{1}{8}$ to $\frac{1}{16}$ in., hile the outer plate in the same time is reduced by less than $\frac{1}{16}$ n., and the stiffeners show very little corrosion. The plates are itted and eaten away in some places more than in others. There practically no scale found on the jackets, but when cleaned onsiderable iron oxide is found in the bottoms.

With an action so marked, serious trouble would be expected the boilers, but, on the contrary, a recent inspection by a

boiler insurance company gave an almost perfect report on the large boiler-plant, which consists of eight 500-h.p. Sterling boilers. There was no pitting in the tubes. The inspector's attention was particularly called to the pitting of the jackets. The cast-iron impellers of rotary pumps that pump to the cooling-tower from the hot-well are pitted in spots quite as deeply as the jackets. A sheet-iron pipe 0.25 in. thick that has carried all the hot water for the jackets of eight furnaces has never leaked. Some wrought-iron pipes, handling water at a temperature of from 65° to 80° F., have been almost destroyed by pitting, while others in the same line have not shown a leak.

These notes are offered in the hope that some member of the Institute may have met this problem before, and can throw light on this interesting subject.

Discussion.

William Kent, Syracuse, N. Y. (communication to the Secretary*):—The analysis of the water shows it to be somewhat unusual; it is rather high in sodium and potassium sulphates and chlorides, 24.58 grains per gal., and very low in calcium carbonate, 0.261 grain per gal. There are three theories which may account for the corrosion:

1. *Air-Bubbles Lodging on the Iron.*—It is well known that even pure water, such as the water of condensation from steam heating-systems, is an active agent in causing the pitting of the nipples used for connecting cast-iron radiators and the iron or steel return water-pipes, and the presence of air in the water is supposed to be the real cause of the corrosion.

2. *Electrolytic Action.*—The water containing sulphates and chlorides may act as an electrolyte, and different portions of the steel plate, having slight variations in chemical composition, may act as two different metals or electrodes.[1]

3. *Chemical Action.*—At certain temperatures potassium sulphate may attack iron, forming iron and potassium sulphate.

Possibly all three of these actions may take place at the same time.

The remedy indicated is the addition of a little milk of lime

* Received July 17, 1907.

[1] See Dr. Cushman's paper on Corrosion, read at the 1907 meeting of the American Society for Testing Materials.

to the water. This will neutralize any acid reaction of the potassium sulphate, and form a precipitate of calcium sulphate, which will make a protective coating on the iron and prevent all three of the actions above described.

JAMES DOUGLAS, New York, N. Y. (communication to the Secretary*):—The following extracts from correspondence with Mr. Lee give some additional particulars concerning the corrosion of the jackets:

DOUGLAS, ARIZ., June 12, 1906.

We have just taken out from one of our new furnaces a jacket, which has been in use five months. I find the same trouble as before: the inner sheet is very badly pitted. The outer sheet and the angles that space the inner and outer sheets do not appear to be attacked.

In connection with this, I wish to call attention to the fact that our boilers, which have been in use now for two years, have just been inspected by the insurance company and have received an almost perfect clearance. Apparently the corrosion is due to some peculiar condition that exists with the fire on one side and water on the other; and also that there is a difference between this condition and that obtaining in the boilers. The steel plate on the outside, which is much thinner to start with, and which is air-cooled on one side, with hot water on the other, far outlasts the thicker inner sheet, and the T-irons, or angles, which are immersed in the water between the two sheets, seem to be very little attacked.

In connection with this peculiar action, I would call attention to the impellers in the rotary pumps which circulate the water for the condensers in the power-plant. These are made of cast-iron; and we find that at certain points they are very badly pitted, being eaten away to a depth of a quarter of an inch for a space of one to two inches in area; and right next to this there will be spaces that are apparently not attacked at all. We have had whole lengths of pipe, leading from the supply-tanks to the power-house, which were perforated, and lengths next to them apparently very little attacked. The surface of the jacket seems to be more uniformly attacked, but even on this there are smooth spots that have apparently resisted this action.

You will see from the above that materials as different as flange-steel and cast-iron are both attacked by the water; that steel exposed to very hot water, such as exists in the boilers, is apparently not attacked; that pipes handling water not over 75° F. are attacked; that pumps handling water both cold and moderately heated are attacked; and that steel surfaces heated on one side and with water on the opposite side of, say, 140 to 150° F., are badly attacked, while plates cooled on one side by the air and exposed to the same water, are very little attacked.

I suggested that samples of the inner shell and a stay-bolt be sent for inspection by the members of the Institute, and that the temperature of the water in contact with the inner and the

* Received Sept. 28, 1907.

outer shell be taken. To this request the following reply, dated Dec. 11, 1906, was made:

Complying with your request, I am sending to-day, by express, a stay-bolt and piece of metal from a water-jacket. The temperatures which you suggested taking of the jacket-water near the inner sheet and near the outer sheet have been taken repeatedly, and I inclose a statement showing the range of temperature. You will note that, as the temperature increases, the variation also increases. We have just now a report from the inspector of the Hartford Boiler Insurance Co., in which we are given an absolutely clear bill on the entire battery of boilers, six of which have been in use 3½ years.

I believe I told you on your last trip here that we are now making experiments by feeding oil into the water as it goes to the jackets, with the hope of coating the inside of the jacket with a film of oil, and possibly preventing the corrosive action of the water.

Temperature of Water in Jackets Near the Inner or Fire Side and Outer or Air Side.

Outside. Degrees F.	Inside. Degrees F.	Outside. Degrees F.	Inside. Degrees F.
97	106	104	115
98	107	106	115
98	108	108	118
102	112	116	130

In answer to a request as to the effect of this oil, Mr. Lee wrote Aug. 28, 1907, as follows:

I am in receipt of your wire of the 22d in regard to corrosion of water-jackets. Apparently the use of oil has been of some benefit in reducing this corrosion, as the amount of jackets renewed seems to be little more than it was, though the number of jackets in use is considerably larger. I recently had occasion to examine a jacket which had been taken out, and found a very peculiar condition: namely, there was a place about 6 by 8 in. right in the middle of the plate which seemed to be quite smooth and not pitted at all, while all around it was very badly corroded. This jacket had been in use about a year and a half.

I have received a very interesting letter from Mr. Beardsley, who was formerly with the Mount Lyell Co. in Tasmania, giving me a number of experiences that he had had of corrosion of jackets, and, as far as he was able, the causes. In one instance well-water was substituted for the former supply. The well-water seemed to be highly charged with gas, and they experienced great difficulty from the jackets burning. This he attributed to the formation of gas-bubbles on the fire-sheet. By mixing the city water and this water the trouble was very much reduced, and a return to the city water stopped it entirely. This, of course, is quite a different experience from ours, which is not one of burning, but one of interior corrosion.

The following letter, dated London, Sept. 17, 1907, is from George M. Douglas, a member of our staff, who was an engi-

neer for some time on the White Star and other steamship lines:

On reading the correspondence you have received from Mr. Lee at Douglas regarding the corrosion of the inner plates of the furnace-jackets, I suggest that this might perhaps be caused by some electrolytic action. This same corrosion takes place in the Scotch type of marine boiler, particularly when the water contains a little salt. This boiler is somewhat analogous in form with the jacket, having a hot inner plate, a water space, and relatively cool external shell.

This corrosion is prevented by hanging zinc plates on the stay-rods between the spaces affected. It is also a practice to put zinc plates near the water-inlet, so that any free acid in the entering water may combine with the zinc and be neutralized.

Perhaps a similar application of zinc to the jacket-shells at Douglas might prove beneficial. I suggest applying it in the following manner: The zinc plates should be about ¾ in. thick, about 8 in. wide, and 16 in. long. Some authorities object to the application of zinc direct to the iron, though it is customary to do so in British engineering practice.

A suitable means would be to have brackets made of copper strips, ¾ in. by 1.5 in., placed about a foot above the bottom of the jacket on the inner shell, into which brackets the plate could be inserted from the top. I also suggest that a plate be put where the jacket-water enters. Two plates of the size mentioned on each side and one on each end of jacket (should there be any corrosion there) is enough. I do not know what the size of the furnaces is. But the relative proportion of zinc surface to iron surface should be about one to ten. A good contact should be insured between the zinc and the copper and iron, or, if copper is not used, between the zinc and iron.

It is not enough merely to place the plates in the water space; they should be well fastened to the jacket.

Under the same date, Mr. Douglas, in response to an inquiry from me, made, in substance, the following statement, which, although not directly pertinent to the present discussion, may be valuable as a contribution to the general question of the corrosion of steel and iron:

With regard to the corrosion of stern-posts and plates in the vicinity of propellers on ships, I should say that this action seems to be well understood as due to the fact that the propeller-blades, etc., on one hand, and the stern-posts and plates, on the other hand, are of different material, so that a galvanic action is set up, the salt water acting as an electrolyte. If all these parts were of exactly the same material, no corrosion would take place; but this is not the case in practice. The stern-tube is usually of bronze, and the propeller of bronze or steel, with blades of manganese bronze. An interesting case is on record, of a vessel on which iron propeller-blades were replaced by blades of bronze. Immediately upon this change, the corrosion of the stern-post and surrounding plates became so great they had to be renewed after only one voyage to the Cape. They were afterwards protected by zinc sheathing; and it is now the custom to protect such parts by sheathing of zinc or some metal of similar electro-chemical character.

Though these facts are interesting, I fear they will not help you much in deal-

ing with your jackets, since the conditions of your problem are by no means the same as those of the marine practice above stated, in which both the origin and the remedy of the trouble seem to be clearly established.

With regard to the general question of the corrosion of steel or iron plates, however, I may call your attention to one point which may be worthy of consideration—namely, the electro-chemical relations between metals and their oxides. According to a leading author,[2] "every metal is electro-positive to its own oxide." When steel or wrought-iron, with oxide scale upon it, is placed in an oxidizing liquid, the conditions of active corrosion are complete; and even without a specially oxidizing medium, it is asserted that a galvanic action may be set up in the presence of air and moisture between the metal and its scale. It is therefore regarded as very important that no "black oxide" should be left on the plate; for, though in itself it tends to protect the surface (the black or magnetic oxide of iron resisting ordinary oxidizing agents), yet if, in finishing, handling, or subsequently using the plates, portions of it should be knocked off, the remaining portions contribute to the corrosion of the exposed metal.

In 1879, Sir Nathan Burnaby declared, as the result of his observation, that when mill-scale was left upon plates and angles used in ships, its effect upon neighboring surfaces of bare metal was as strong and continuous as that of copper.

In 1882, Mr. Farquharson conducted for the British Admiralty, at different naval stations, exhaustive experiments as to the action of mill-scale on ships' metal exposed to the conditions of marine use, and found: (1) that no "pitting" occurred in mild steel *freed from all scale;* (2) that the loss of weight by corrosion was practically the same for clean mild steel and clean iron; and (3) that the action of mill-scale in inducing corrosion is considerable and continuous—equal in these respects to that of an equal amount of copper.

The Admiralty practice is to pickle all ships' metal, for the removal of mill-scale. The scale may also be removed by the sand-blast, or by means of a gasoline-torch, followed with a scraper and a wire brush. Pickling, however (in dilute sulphuric or hydrochloric acid), is probably more thoroughly effective.

The rivets should be of the same material, as the plates. Iron rivets in steel plates might cause trouble.

HIRAM W. HIXON, Victoria Mines, Ontario, Can. (communication to the Secretary *):—I have had difficulties here similar to those encountered at Douglas, and I found the cause to be the carbonic acid given off when the water was warmed. All the water in the streams in this country contains organic matter coming from peat-bogs and muskegs. It is brown in color, and when it strikes the fire-sheets of the jackets the carbonic acid is given off and travels up along these fire-sheets because of the bosh in the furnace. The lower side of the tuyeres was

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[2] *Metallic Structures: Corrosion and Fouling, and Their Prevention*, by John Newman, p. 36. London: Spon & Chamberlain (1896). See also, *Rustless Coatings, Corrosion and Electrolysis of Iron and Steel*, by M. P. Wood. London: Chapman & Hall (1904).

* Received through Dr. Douglas, Sept. 28, 1907.

much pitted, and they leaked badly until I had copper tubes put in in place of iron ones.

The inner or fire-sheets were destroyed most rapidly opposite the cold-water inlet, where the greatest amount of carbonic acid was given off. Our boilers are not affected and are perfectly clear of scale. I think the acid is liberated in the feed-water heater, in which there are copper tubes, and after it is in a gaseous condition it does not attack iron, or at least the water is necessary to make it destructive. The pipes leading from the feed-water heater to the boilers are destroyed, but the boilers are not.

The Canadian Copper Co. had a purifying plant for the feed-water, and the pipe leading from the purifier to the different boilers went over the boilers, and each lead to the boiler came out of the bottom of the main pipe. Tests made of the water to the different boilers showed that the water to the boilers nearest the purifier was much less acid than the water to the boiler at the end of the feed-pipe. The superintendent spoke to me about it, and I suggested that the acidity of the water was due to carbonic acid dissolved in the water, and that being a gas it had a tendency to enrich the water in the top of the feed-pipe, and, consequently, the water drawn off for the first boiler from the bottom of the main contained less acid than the water which went to the last boiler.

I think the trouble at Douglas is due to the water-supply coming from the deep wells containing carbonic acid, and this acid is probably due to the source of the water being something in the nature of a mineral spring, such as Saratoga, Manatau or Apollinaris. Ordinary chemical tests would fail to detect any mineral acid, and the gas being small in quantity would escape detection.

The remedy for the trouble is to use copper fire-sheets, or to run the water through cooling-towers and use it after the carbonic acid has escaped.

C. D. Van Arsdale, New York, N. Y. (communication to the Secretary*):—There are several explanations which present themselves regarding the corrosion of the water-jackets of the

* Received Oct. 31, 1907.

Douglas furnaces. The most obvious of these—namely, that the composition of the water is itself directly responsible—may be dismissed as improbable. Analysis of the water shows that it may be called a good boiler-water for this region, since it contains very small amounts of incrusting solids and the non-incrusting solids are not excessive; and this opinion is verified by its causing practically no boiler-troubles. Since no corrosion takes place in the boilers, it is evident that the dissolved constituents of the water do not alone afford sufficient explanation of the trouble.

Granting that the water is itself non-corrosive, there is nothing in the working of the ordinary water-jacket to account for the difficulty, otherwise such corrosion would be more or less generally observed in other plants. It would, therefore, seem that the only explanation left is electrolytic action; but it is not evident what is the cause for the electrolysis.

It is well known that lack of uniformity in the composition of iron will cause corrosion on account of action due to minute local galvanic couples. If this is the cause, then a suitable remedy would be to hang zinc sheets inside the jackets, as has already been suggested. Another cause of electrolytic corrosion may be stray currents from some source. In the same way much trouble has been experienced from corrosion of gas- and water-mains in cities, due to stray electric currents passing along them. A very small current has been found sufficient to cause a great amount of trouble, but if this should be found to be what is causing the electrolytic action in the jackets, it should be quite simple to put a stop to it.

The different temperatures observed in different parts of the jackets might also be sufficient to cause some corrosion, since electrical currents can be produced in an electrolyte by electrodes of the same metal, portions of which are at different temperatures. This could be obviated by a circulation of water in the jackets sufficiently rapid to do away with any differences of temperature.

The fact that the jackets are much more corroded on the fire side seems to indicate that the electrolytic action is due not to lack of uniformity of the iron, but to one or both of the other causes mentioned.

UBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Diamonds in Arkansas.

BY GEORGE F. KUNZ, NEW YORK, N. Y., AND HENRY S. WASHINGTON, LOCUST, N. J.

(New York Meeting, February, 1908.)

THE recently discovered occurrence of diamonds near Mur-freesboro, Pike county, Ark., was brought to our attention by Mr. Samuel W. Reyburn (Trustee for Messrs. C. S. Stifft, A. D. Cohn, August Zinsser, Jr., and himself, owners of the property), through whose courtesy we investigated the locality of the deposit. Prospecting with the diamond-drill is now in active progress; but mining operations on a large scale have not yet been ordered.

Geology.—The geology as well as the petrography of this interesting locality has been well described by Messrs. J. C. Branner and R. N. Brackett.[1] Briefly summarized, the igneous rock in which the diamonds are found is a vitreous peridotite, forming a stock or volcanic neck, which has broken up through the Carboniferous and Cretaceous quartzites and sandstones. After an extensive period of erosion, during which an unknown portion of the neck and presumably a previously existent volcanic cone have been removed, the surface was covered with thin beds of Post-Tertiary conglomerate. The volcanic intrusion was accompanied by the formation of several small dikes of a rock much like that of the main body. One of these dikes cuts across the stock, while another cuts the Cretaceous sandstone, but is overlain by the conglomerate, thus giving a datum for the period of intrusion. So far as known, there was little, if any, metamorphism of the country-rock by the igneous magna, which probably followed an approximately vertical course, so that a more or less vertical extension downward of the igneous body to indefinite depths may be expected.

[1] *American Journal of Science*, Third Series, vol. xxxviii., pp. 50 to 59 (1889); and *Annual Report of the Geological Survey of Arkansas for* 1890, vol. ii., pp. 377 to 391 (1891).

This result should hold good, at least, for the upper and most accessible portions, though some departure from strict verticality may be expected at greater depths.

As already observed, the igneous rock is a peridotite which, in fresh hand-specimens, is tough, hard, distinctly porphyritic, and very dark greenish- or brownish-black. Microscopic study shows it to be composed of numerous crystals of olivine and some patches of biotite, imbedded in a ground-mass of very small crystals of augite, perofskite, and magnetite, with an abundant yellowish to colorless glass base. In all the specimens examined by Mr. Brackett or by us the olivines are more or less completely serpentinized, and the glass is apt to show an aggregate polarization due to decomposition. The rock is evidently an igneous intrusive, which probably welled up in comparative quiet, and solidified not far from the surface. It is therefore in no sense a volcanic breccia, due to explosive eruptions, as are most of the South African occurrences. Chemically and mineralogically, however, it much resembles the South African rock, although there are certain points of difference—notably the absence of inclusions.

Peridotites are generally prone to alteration by weathering. In this instance the freshest rock is dense, hard and tough, and does not crumble markedly on exposure, as is evidenced by the fact that the highest points in this igneous area are exposures of fairly-fresh peridotite. The first state of pronounced alteration is the disintegration of the firm rock into a mass of hard angular fragments, varying in size from that of a bean to that of a human fist, which apparently do not readily disintegrate on exposure to the weather. The second stage of alteration, due to further weathering, yields a compact mass, the so-called "green ground," showing various shades of light olive-green, and often bluish in tint when moist, but becoming yellowish on drying. The third state of alteration, found nearer the surface, furnishes, from still further oxidation of the ferrous iron, the so-called "yellow ground," which resembles the "green ground" in physical characters, but is, in color, distinctly brownish-yellow, with little or no trace of green. The green ground and the yellow ground are soft and friable, crumble readily between the fingers, and show soft, but sharply defined, serpentinous pseudomorphs of the original olivine crys-

tals, with well-preserved outlines. This fact, supplemented by the general appearance of the texture, shows clearly that the peridotite has been decomposed in place, and that there has been little or no transportation of the material.

Both the green and the yellow grounds, if dry, crush under a gentle pressure to a fine powder, containing small gritty particles of the less decomposed minerals, which can be readily sifted out. If wet, the rocks disintegrate rapidly, especially with mechanical agitation, to a fine, somewhat sticky mud, which can be easily washed or otherwise concentrated.

The fresh, compact peridotite crops out at the surface, forms several small hills along the NW. border of the deposit, and is also visible at other points; and the first fragmentary alteration-product shows itself at a few spots; but the green and the yellow grounds are found over by far the greater part of the igneous area, either on the surface or, more frequently, immediately beneath a thin layer of black, sticky, "gumbo" soil. The maximum and average depths of this mass of decomposed peridotite have not yet been exactly ascertained; but borings show it to be, in places, 40 ft. thick. This fact, together with other considerations, leads us to estimate the average thickness to be not less than 20 ft. Below this is found either the fragmentary, or a more or less compact, igneous rock. One drill-hole has penetrated the peridotite to a depth of 205 ft., another to 186 ft., and a third to 80 ft.—all remaining in igneous rock to the end, as was to be expected, in view of the geologic structure.

The surface exposure of the igneous area forms a rough ellipse, about 2,400 ft. in major and 1,800 ft. in minor diameter. The area known to be underlain by peridotite is estimated at about 40 acres, though further prospecting of the neighboring alluvium-covered bottom-land to the south may possibly add to this amount. The limits in other directions are more clearly marked.

General Conditions.—A variable supply of water, usually abundant, is furnished by the Little Missouri river, which flows a short distance to the southwest of the igneous area. This stream, though somewhat low at certain seasons, never runs dry, and may be safely counted on to provide a sufficient supply of water for all mining purposes. For certain installations,

however, its rapid and sometimes serious rises must be taken into consideration. The owners of the igneous area possess, also, a large tract of land, along both sides of this stream, with the incident water-rights.

A large portion of the land under control is well wooded; and extensive forests, chiefly of pine, with some oak, promise a good supply of cheap timber for some years to come.

Coal may be readily purchased at a reasonable cost from the bituminous fields of Arkansas, the Indian Territory, or Texas.

Although the region is not thickly settled, and the nearest towns are small, the experience of the lumber-companies indicates that an ample supply of labor (chiefly white) will be available. Indeed, the lumber-camps themselves may be an immediate source of supply. In this connection an obvious, and possibly serious, difficulty may be mentioned—namely, the prevention of the loss of diamonds through theft by the laborers. With the class of labor employed at the South African mines, a system of detention in compounds, thorough physical examination for hidden diamonds, and other methods for the prevention of theft or the recovery of stolen stones, can be carried out; but in the United States it might be impossible to employ, at least in a thorough-going manner, safeguards of this character. Up to the present time, a small force of picked men having been employed in the preliminary operations, and about 140 diamonds having been found, there is little or no ground for the belief that any serious loss of this kind has occurred. But work on a large scale, involving the employment of a large number of laborers of less trustworthy character, and increased difficulties of adequate supervision, will augment this risk, the prevention of which will be a serious problem.

Transportation facilities for coal, machinery and other supplies are furnished by two short branches from the Iron Mountain Railroad. One (a private lumber road) leaves the main line at Prescott, and extends 26 miles to Nathan, about 6 miles from Murfreesboro, while the other runs from Gurdon on the main line about 30 miles to Pike City, distant about 10 miles from Murfreesboro. Only very rough roads now connect these terminals with the diamond-bearing locality; but the improvement of these roads, or the extension from Murfrees-

boro of another railroad, may be safely counted upon in the near future.

Factors to be Determined.—Up to the present time about 140 diamonds have been discovered within the igneous area, while none have certainly been found outside of it, even in the immediate vicinity. All the stones have been found on the surface, except two, which were in the concentrates derived from washing large amounts of the green ground, and one, which was imbedded in the green ground itself about 15 ft. beneath the surface. Our careful examination of this last specimen, confirmed by Dr. R. W. Raymond, leaves no doubt that the diamond is actually in place in the rock and was not inserted in the specimen. Consequently it constitutes a definite proot that the peridotite is the source of the diamonds, and that all the stones so far discovered have been derived from it. It would be well, however, to have this single piece of evidence corroborated by similar specimens. With regard to the quantitative relations of the diamonds to the inclosing rock, about 200 carats have been found on or immediately beneath the surface, where presumably there has been considerable concentration of the stones. From the nature of the deposit, the average yield per ton can only be ascertained by actual washing or other extraction from the rock on an extensive scale, commensurate with that of purposed commercial operations.

Additional factors of economic importance, for which more extensive data are necessary, are the average size, color and quality of the stones, since these factors determine their value. From the 200 carats at present available for examination, it appears that the Arkansas locality compares very favorably with most, if not all, of those in South Africa. Although no stones larger than 6.5 carats have yet been found, the average size is fairly good. There is a large proportion of white stones, for the most part of a high grade in color, brilliancy, and freedom from flaws. Indeed, many are as fine as have ever been found. Some of the yellow ones, also, are of exceptional quality and color.

A more exact determination of the limits and extent of the workable area, based on a large survey and on extensive prospecting with the drill, is now being made.

The method of extraction of the diamonds is of vital in-

terest and importance. The green and the yellow grounds offer no difficulty, and are amenable to the methods used in South Africa. Indeed, in Arkansas, there is no need for prolonged exposure to the weather, since the freshly extracted material disintegrates and can be washed with ease. The amount of this easily worked material "in sight" is very large; yet, it is not of indefinite extent downward, as is the "blue ground" of Kimberley; and, consequently, its extraction will form but a transient phase of future exploitation.

The economical extraction of the diamonds from the compact, and relatively fresh and hard, peridotite, underlying the "green ground" and forming the vast bulk of the mass, will involve study, and probably experiment. But, apparently, there will be no greater difficulties than have been successfully overcome in South Africa. In view of the hard, tough, and fresh character of the peridotite which composes the highest points of the area along the NW. border, it might be thought that the material underlying the green ground would be of the same character and equally refractory; but the diamond-drill shows that, at least for considerable depths, a large proportion of the underlying peridotite is far more decomposed than that which crops out at the border—is, indeed, so far altered that much of the material comes up as sludge, and no continuous cores longer than 14 in. have been obtained. Many of these cores were so soft as to be readily scratched with a knife. Probably this more compact material will disintegrate on exposure to the weather, like the South African "blue ground." If this proves to be the case, a large proportion of the mass will not be difficult to work.

At some portions of the mass, however, as at the NW. border, and presumably in depth beneath the rest of the area, fresher and much more refractory material will be encountered, the treatment of which will present practically the same problem as that of the hard portions of the African rock which do not disintegrate on exposure. While a certain amount of crushing, in order to extract the diamonds, is apparently unavoidable, this should be reduced to a minimum, on account of a high loss from breakage of the stones themselves. Several methods of treatment suggest themselves, which are at present under advisement; but the practical details, as well as the

economic features, remain to be worked out and cannot be discussed here. The non-magnetic character of the diamond and its tendency to adhere to grease are obvious features which can undoubtedly be used at certain stages of the extraction for all classes of material in the Arkansas deposit, as in South Africa.

A Word of Warning.—In view of the great local excitement over the discovery of diamonds, which has extended over part of the State, and in view of the danger of the repetition here of the disastrous history of many mining camps which have undergone an unwarranted "boom," and the consequent rush and loss of time and money by many innocent individuals, it should be distinctly understood by the public that the occurrence of diamonds near Murfreesboro is an isolated one, and that it does not resemble a mineral vein or lode in any respect. Consequently, there is not the least justification for any such claims as will undoubtedly be made by ignorant or unscrupulous parties, that "a continuation of the vein" has been struck. There can be no continuation of a vein when there is no vein.

Should other similar igneous areas, which may possibly be diamond-bearing, be discovered elsewhere, any claims put forward for them should be received with the greatest caution. Fortunately, the characteristics of the peridotite (in which, by analogy, diamonds may be most reasonably expected to occur) are so easily recognizable by a petrographer, the localities will be presumably so isolated, and the outlines and extensions of the mass so well defined, that the report of a geologist or petrographer can surely prevent an unsuspecting or ignorant person from loss by investment in a property said to be a continuation of, or a connection with, the present deposit.

Peridotites are not uncommon; but very few are diamond-bearing. Indeed, the great majority of these rocks found all over the world show no trace of diamonds. Even in South Africa, many peridotite pipes, resembling valuable ones, carry no diamonds, while in any diamond-bearing pipe some portions are found to be richer in diamonds than others.

As shown by J. F. Kemp,[2] many basic dikes have been

[2] J. F. Williams, *Annual Report of the Geological Survey of Arkansas for* 1890, vol. ii., pp. 392 to 406 (1891).

found in Arkansas; but most of these differ petrographically from the Murfreesboro peridotite, and there is no reason to think that any of these, or any of the several syenitic areas of the State, are connected with diamond-bearing rocks. As has been noted above, two dikes of peridotite occur in connection with the Murfreesboro igneous area. Great stress is laid locally on these dikes, or "leads," as they are called, but without warrant, since there is no reason to think they contain diamonds, and in any case they are too small to be of economic value. From analogy with other igneous intrusions, it is probable that more dikes will be discovered in the neighborhood, radiating out from the main stock; and in other localities the presence of dikes of similar rock, which could only be identified by petrographical means, would be an indication of the possible presence of a larger body of peridotite in the vicinity. If diamonds are present, they are to be looked for in the rock-mass itself, or in its products of weathering, and not only along the contacts, because they are integral portions of the igneous mass, and their presence is not due to the circulation of hot water and solutions along the contact between an igneous mass and the country-rock.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Dip and Pitch.

BY R. W. RAYMOND, NEW YORK, N. Y.

(New York Meeting, February, 1908.)

PROF. HENRY LOUIS, of Armstrong College, Newcastle-on-Tyne, England, a distinguished member of this Institute and other technical societies, has recently sent to the Institution of Mining Engineers, and to the Institution of Mining and Metallurgy, in Great Britain, a communication, the substance of which is as follows:

Prof. Louis calls attention to the absence of any recognized English term for the definite description of a frequent phenomenon—namely, the oblique position of an ore-body in the plane in which it lies. In this connection, Prof. Louis says that in America the term "pitch" has been occasionally applied to this relation, and proposes that, in the literature of ore-deposits, it shall be hereafter restricted to this particular meaning, the angle of the pitch, like that of the dip, being always measured from the horizontal, and the dip being always taken at right angles to the strike, while the pitch is taken on the plane of the dip, in the direction of the strike. Thus, for example, in a vein or bed striking N–S., and dipping, say, 45° E., there might be an ore-body, the axis of which pitched northward, at an angle of 45° below the horizontal line, as measured on the plane of the inclosing vein or bed. If the term "pitch" had this universally recognized meaning, the situation could be simply and perfectly expressed by its use, in connection with the general data of strike and dip. As Prof. Louis says:

> "This suggestion has a certain practical value, and is not merely academic. Every mining engineer of practical experience in such types of ore-deposit will have met with cases, in which a vertical shaft has been sunk with the object of cutting the deposit, but has missed it, because the dip alone has been taken into account, while the pitch has been overlooked."

He adds the acute observation that such an oversight is much likelier to occur with regard to a condition not definitely desig-

nated, and therefore not invariably recorded. Finally, he points out that if the dip and strike of the inclosing vein, and the pitch of an included ore-body, be stated, the actual dip and strike of the latter can be determined by a simple geometrical construction, and hence need not be directly measured. Of course, if a given ore-body pitches 45° N. in a bed or vein which strikes N–S., and dips 45° E., that ore-body must be constantly making to the eastward with increasing depth; but the direction which it thus pursues can be, as Prof. Louis shows, easily determined without additional surveys, from the dip and strike of the inclosing zone and the pitch and general direction of the body itself.

To the proposal thus advanced by Prof. Louis, I would give my hearty assent, pointing out, however, that the American usage which embodies it, and which he describes as "occasional," is practically universal. I know, at least, that I have followed it for forty years; and I do not think any instance to the contrary can be found in the 27 volumes of our *Transactions* which I have edited.

On the other hand, it is always somewhat perilous to limit the meaning of a term, previously employed in a looser sense; and there is no doubt that "pitch" has been often, and is still sometimes, used as synonymous with "dip." In view of that fact, I would suggest that, while mining engineers, following Prof. Louis's excellent suggestion and our general American practice, use the term "pitch" exclusively in the sense he proposes, they take pains, at the same time, to avoid misunderstanding by invariably stating, together with the "pitch" of a body, the dip and strike of the vein or bed in which it occurs. Indeed, without these explanatory particulars, a statement of the "pitch" would have relatively small value; whereas, taken together with them, it would not only preclude all misunderstanding, but also furnish to the mining engineer all the data required for the planning of underground work.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Bogoslovsk Mining Estate.

BY WILLIAM H. SHOCKLEY, TONOPAH, NEV.

(New York Meeting, February, 1908.)

I. Introduction.

There was an extensive mining and industrial exploitation of Russia, about 20 years ago, by Belgian, French and British capitalists; but the results were discouraging. It is said that the Belgian and French public together lost approximately $400,000,000, chiefly in the coal and iron industry of southern Russia. This loss is largely accounted for by the fact that most of the companies were formed, as usual in "boom" times, to sell stock; and that thorough investigations were not made.

In 1906, renewed interest was taken in Russian mines, especially in those of gold and copper, and a considerable literature is growing on this subject; but as yet I have seen no account of one of the large Russian mining estates. The following notes on such property, where the conditions are so different from those in the mining regions of the United States, should be of interest:

This inadequate and probably somewhat inaccurate account is made up, partly from my own notes made on the ground, in the summers of 1904 and 1905, and partly from a volume on the geology and resources of the estate issued several years ago, containing surface- and mine-maps, and from a pamphlet published in 1904, giving a general account of the condition and prospects of the property. This pamphlet includes a report made by Arthur L. Pearse, a member of this Institute, in 1899. Both these books are in Russian, and were prepared by the Bogoslovsk Mining Co., which owns and operates the property.

Articles in many other languages have appeared dealing with various matters connected with the estate; but I know of no other general account of it. In numerous books and articles on the Urals and Siberia, however, localities are described in which somewhat similar conditions prevail. Recent papers by

Dr. F. H. Hatch and Mr. A. L. Simon in the *Transactions of the Institution of Mining and Metallurgy*, contain notes of special interest to mining engineers. See also my notes on Gold-Dredging in the Urals.[1]

The Bogoslovsk estate lies in the low rolling hills east of the summit of the Ural range, and is geographically in Siberia, though politically in the Perm government of European Russia. Its irregular area of 3,600 sq. miles extends 144 miles N–S., with an extreme breadth of 53 miles; the town of Bogoslovsk, near the center, being in lat. 60° N., long. 60° E. The estate also owns some outlying areas. While exceeded by the immense private properties of the Czar and by some others (such as that of the Prince of Thurn and Taxis, which is said to comprise 40,000 sq. miles, of which 17,560 belong to the Domains Co., Ltd., of London), this is one of the largest in the Russian Empire and ranks with the great estates of the world.

I do not know the exact conditions under which the property is held: 1,469 sq. miles are forest lands, rented from the government for 100 years, with certain rights over the minerals; and the remainder seems to be owned in fee simple.

The forests are considered by local experts to constitute its chief wealth. Since the building of the branch railway connecting with the main lines at Goroblagodatskaia, several sawmills have been started, and some of the lumber will be shipped to London via Archangel. The forest is used at present mainly to supply charcoal, the chief fuel for iron- and copper-smelting.

Among the other resources are deposits of vein- and placer-gold, and of platinum; ores of copper, manganese, iron and chromium; beds of lignite; refractory furnace-materials; limestones; and cement-rock.

The company makes pig-iron from its ores in charcoal blast-furnaces, and converts this into steel, which it manufactures into rails and structural forms; smelts the copper-ores; and makes sodium and potassium bichromate, fire-brick and furnace-linings. Glass-, cement-, and phosphorus-works have been established, but are now idle.

The estate was famed for its riches in iron and copper in the last half of the 18th century, when iron- and copper-smelting

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[1] *Trans.*, xxxvii., 322 to 330 (1907).

was begun by private individuals, to be continued later by the Crown, with convict-labor. A few exiles are still sent to this region. They are not allowed to cross certain boundaries, but are free to choose their occupations. In 1875 the estate passed into private hands, and in 1885 it was given by Baron Stieglitz (who had bought it for $3,000,000) as a birthday present to his daughter, who has retained the ownership, operating the property since 1895 through the Bogoslovsk Mining Co., which she controls. It is said that she has never visited the tract, though her husband was there once for a few days, and her sons have been there for longer periods; and that she has never received a kopeck of income from it—the reason for this being, that any profits realized are at once put into improvements, which constantly call for fresh expenditures. The capital already employed is about $15,000,000, and much more could be used with advantage. Fig. 1 shows the residence of the General Manager, and other buildings, and Fig. 2 is a view of the town of Bogoslovsk as seen from the smelter.

II. Management.

A notion of the many activities comprised in this administration may be gained by analyzing the general expenditures, stated for 1904 at $164,285, according to the "Smieta" or estimate for that year. Such an estimate, comprised in two or more printed books, and covering in detail all the operations of the business, is prepared at the close of each year, and all the expenses of the next year are predicted to a kopeck. The remarkable thing is, that, as a rule, the results agree very closely with these predictions, the difference between the expected and the actual amount of ore produced in the mines, for example, being only a few per cent. In this particular, such a correspondence means, of course, that the mines are worked in a leisurely manner, and that the mine-managers always have ore-reserves, or stocks on hand, to cover all possible delays—something after the manner of the "secret" gold reserves of Australia and the Rand. In my judgment, this detailed preliminary estimate is probably, on the whole, a detriment to the proper working of the mines, making the engineers in charge too cautious, and retarding the development of the properties; it has, however, the advantage that the owners are not called

on unexpectedly for large sums of money to meet unexpected emergencies or new improvements suddenly called for.

The estimate of general expenses for 1905 was as follows:

Central office expenses,	$26,204
Post and telegraph,	3,800
Messengers,	4,347
Buildings and rooms,	4,841
Fire-prevention,	1,640
Mining-school,	4,650
Children's asylum,	2,799
Old men's home,	806
Geological museum,	3,350
Technical bureau,	5,149
Library and reading-room,	1,113
Telephone service,	6,542
Repairs to buildings,	3,908
Roads and bridges,	690
Medicines,	21,068
Taxes,	31,570
Insurance,	20,000
Help to unfortunates,	8,250
Flour,	3,500
Wages to mining students,	1,580
Sundries,	8,478
	$164,285

In this statement, "fire-prevention" refers, for the most part, to forest-fires; the "mining school" covers a general as well as a technical education; the "geological museum" represents principally the geological survey of the estate and mines, and makes a specialty of petrography, having 80,000 rock-slides on hand at the end of 1904; free medical attendance and free medicines are both, I believe, required by law; and the "wages to mining students" are paid to students from the Royal School of Mines in St. Petersburg, who act, during the summer vacation, as assistants to the engineers, studying special problems and receiving $25 per month salary. They add much to social life during their visit. By reason of political troubles at their school, at the time of my visit, a number of them had been requested to remain on the estate for a year. The managers, however, did not seem desirous to have this number increased.

The Russian mining laws should be carefully studied by foreigners mining in Russia, and pains should be taken to keep on the right side of the officials. The subordinates do not

object to presents; but it is not wise to attempt to purchase immunity for violations of the law. The most alarming provision of the law is that which makes a manager personally liable for accidents, even punishing him with imprisonment. This, however, can be avoided by having a Russian nominal manager to bear this responsibility. Foreigners engaged in mining in Russia tell me that they have very little trouble with the laws.

III. General Conditions and Labor.

The climate is healthy. There are no peculiar local diseases. The maximum summer temperature is 90° F.; the lowest winter temperature —55° F. Winter is the active season for forest-work, as the roads are almost impassable swamps in summer. Insect pests are troublesome in summer. The rivers abound in fish, and the forests in berries. Owing to lack of enterprise, there is but little agriculture on the estate; but many crops could be grown, and it is an excellent dairy country. The average rainfall for several years was 15 inches.

There is a population of 35,000 on the estate. The greater portion of the hard work is done by Tatars from the province of Kazan on the Volga, who usually remain on the estate but a few months at a time, their movements being regulated by the seasons of planting and harvest. They are excellent workers, but poorly trained. Until 1906 no strikes had been known; but in that year the general unrest reached the Urals, and there a number of (not very serious) strikes took place. As a rule, the workmen are very patient, and make no trouble, even if their wages are some months in arrears.

The usual dwellings are log houses, and those of the managers and engineers are very comfortable. At some of the mines, the workmen are housed in large buildings of one room with bunks around the sides. The single men occupy one building, and the married men with their families another. Women work on the surface but not underground in the mines; they sort ore, drive carts, and labor with the leasers on the placers.

The natives of the Urals are noted for their independence. They are much more prosperous than the agricultural laborers of Central Russia.

The following statements will show the general conditions of living:

Prices in Bogoslovsk in 1904.

Dynamite (92 per cent. gelatine),	$0.45 per lb.
Fuse,	0.35 per 100 ft.
Caps,	1.15 per 100.
Wood,	1.50 per cord.
Coke,	13.85 per 2,000 lb.
Charcoal,	4.25 per 2,000 lb.
Candles,	0.10 per lb.
Flour,	55.00 per 2,000 lb.
Butter,	$0.20 to 0.25 per lb.
Potatoes,	8.30 per 2,000 lb.
Beef,	$0.04 to 0.06 per lb.
Mutton,	none
Pork,	none
Ham,	0.14 per lb.
Vodka,	0.35 per liter.
Quass,	0.20 per pail.
Rye,	27.50 per 2,000 lb.
Partridges,	0.15 per pair.
Capercailzie,	0.40 each.
Wild geese,	0.40 per pair.
Salt, coarse,	8.30 per 2,000 lb.

Wages at the Frolovsky Copper-Mine.

Foremen,	$22.50 to $25.00 per month.
Shift-bosses,	15.00 to 17.50 per month.
Time-keepers,	9.00 to 12.50 per month.
Clerks,	50.00 to 150.00 per year.
Hoisting-engineers,	20.00 per month.
Pumpmen,	12.50 to 17.50 per month.
Wood-carriers,	10.50 per month.
Boys,	5.00 to 7.50 per month.
Blacksmiths,	12.50 per month.
Blacksmith-helpers,	10.00 per month.
Head machinists,	32.50 per month and room with fire.
Shaft-men,	0.43 per diem.
Mine-drillers,	0.38 per diem.
Surface-drillers,	0.30 per diem.
Mine-helpers,	0.30 per diem.
Surface-helpers,	0.25 per diem.
Laborers (12 hr.),	0.35 per diem.
Laborers (ordinary),	0.25 to 0.30 per diem.
Women laborers,	0.15 per diem.
Surface-machinists,	0.33 to 0.63 per diem.
Timbermen,	0.45 per diem.

The Frolovsky mine employs 540 men in winter, with 6 clerks in the office, and 52 mechanics. I have no record of

the administrative force of the estate; but there is a small army of officials, all of whom, as well as the students, wear uniforms prescribed by law. (Fig. 3)

The chief Russian characteristic which I noted was an easy, good-natured way of doing business, and an absence of rush; no "strenuous" people were wanted. None of the copper-mine managers had ever visited mines outside of Russia.

Russian holidays are a great detriment to steady work. Including Sundays, there are nearly 100 in a year; and at Easter, after the long Lenten fast, it is considered a duty to drink heavily. When, in 1904, the copper-smelter was kept going during the Easter holidays, it was regarded as a great feat. I saw no drinking, however, among the officials on the estate.

Late reports (August, 1907) from the Urals indicate that there is a strong revolutionary spirit in the air, and that the workmen are giving much trouble.

IV. Transportation.

Transportation between the chief mines and works is performed by the company's 100-mile narrow-gauge railway. The Nadesda works are connected with the main-line Russian railways by a broad-gauge railway 123 miles long, completed in 1905; 8,000,000 roubles (about $4,000,000) having been advanced to the company by the Russian government. Before that time, most of the products of the estate were transported by the company's fleet of steamers, the most distant ports being Semipalatinsk on the Irtish river, and Bieska on the Ob river, each at the end of a voyage of 2,300 miles. Semipalatinsk is approximately in lat. 50° N., long. 80° E.; and Bieska (Busk) in lat. 53° N., long. 85° E.

As this instance shows, the inland water-ways of the Russian Empire, with their vast traffic, are a marvelous advantage, and will be of the utmost importance to the commercial development of the country.

The company's fleet comprises 10 steamers, with a total capacity of 21,000 tons, and 54 barges and boats with 41,000 tons capacity. The freight-movement for 1902 was 117,000,000 ton-miles.

V. Forestry.

The comparatively level surface of the tract is thickly covered with larches, firs, and pines; birches and poplars are less abundant; oaks are wanting. Under the management of experienced foresters, the trees are cut from blocks of 40 acres, surrounded on all sides by uncut forest. On these soon appears a new growth, which will be ready after from 80 to 100 years for cutting again. Some of the blocks thus cleared in 1904 had been cut for the first time in 1819. Under this system, the 1,412 sq. miles of forest are capable of producing 279,000 cords of wood annually. Including 1,150 sq. miles of rented lands the total annual capacity (in other words, the total annual growth) is 549,000 cords. According to the latest data in my possession, 6,000 men and 6,000 horses employed during the winter in this country cut 416,000 cords, or 133,000 cords less than the full forest capacity. The charcoal, made in heaps and in modern kilns, costs $4.25 per ton of 2,000 lb.

VI. Iron and Steel.

The chief industry of the estate is iron-making in charcoal blast-furnaces and the manufacture of steel. The product in 1905 was 75,000 tons, nearly all of which was made into steel. Both the iron and the steel are of exceptionally good quality. The latter is made into rails and structural shapes at the Nadesda works. In 1903 the product was:

54,000 tons of iron, costing,	$8.10 per ton.
63,000 tons of steel, costing,	13.70 per ton.
44,000 tons of rails, costing,	21.08 per ton.

Extensive alterations and additions, since made to these works, have increased their capacity and reduced the cost of their product. It was estimated that, after completion of the works, the iron would cost $6.85 per ton (a figure which, at the present time, is probably surpassed in cheapness only by the iron-furnaces of Shansi, China, where excellent iron is made for $5.00 per ton), and that the annual product would be 83,000 tons, or one-sixth of the total product of the Urals. (Fig. 4.)

In 1905, the motive-power employed at Nadesda amounted to 4,555 h.p. But a gas-engine of 6,000 h.p., made by the Cockerill Works of Belgium, was then being erected, to replace

the steam-engines, and to be run by the waste gases from the iron blast-furnaces. The power in excess of that employed in the iron industry was to be electrically transmitted to the copper-mines. The erection of this large gas-engine, of most modern type, is a creditable illustration of the enterprise of Russian managers in this region. Other instances could be given. Steam-engines were used in the Urals in 1766; and some of the earliest (as the Russians claim, the very earliest) experiments in copper-converting were made there. The Bogoslovsk copper-converter was set up in 1882.

The charcoal pig-iron made on the estate is converted by the open-hearth process into steel of excellent quality, which is, for the most part, rolled into rails and structural shapes.

The quantity of the developed iron-ores, including those of the Northern iron-mine on the Lozva river, has been estimated by Professors Feodoroff and Nikitin at 8,000,000 tons. They are hematites and limonites, containing 30 to 66 per cent. of iron, and occurring in basin-deposits, from 13 to 65 ft. thick, 200 to 650 ft. wide, and 500 to 1,600 ft. long. There is believed to be a great deal of undeveloped ore on the estate and in the Northern iron-mine. The output of ore from 1896 to 1903 was 686,000 tons, mined at a cost of from $1.15 per ton in 1896 to $0.81 in 1902.

The deposits are worked by pick and shovel, the ore being hauled from the quarries in 1,000-lb. loads by wagons, often driven by women. (Fig. 5.)

VII. Gold and Platinum.

Gold is found in both placers and veins. From 1895 to 1902, the product of the estate was $1,750,000. The placers all carry platinum, of which 2,517 oz. Troy was produced during the period named.

As already remarked, the productive Voronsovsky iron-mine was discovered in searching for a gold-bearing quartz-vein. In operating the iron-mine, this vein has been exposed for a horizontal distance of 700 ft., with an average width of 4 ft. It contains a soft clayey material, carrying "bunches" of "rotten quartz," the treatment of 601 tons of which is reported to have yielded $5.87 per ton.

The Alexandrovsky quartz-mine, near the Voronsovsky iron-

mine, has been opened to a depth of 175 ft. by means of a horse-whim. The ore is a soft rock, almost clay, probably a porphyry. Augite-garnet rock and much quartz are also present. It is worked for a width of 38 ft. in a portion of the mine. The ground is very heavy, and is taken out by running closely-timbered drifts 50 ft. apart. These are allowed to settle after being filled with waste while parallel drifts are being run. Eventually all the ore will be extracted. Mining costs in 1904 were $1.56 per ton; the ore-reserves were estimated at 68,500 tons containing $225,000. The ore is broken by hand with hammers, and worked in a Chilean mill, containing two iron wheels of 55 in. diameter by 11 in. face, and weighing 5,400 lb., which revolve in an iron pan and make 9 rev. per min. They are run by a 12-h.p. engine, and crush 23 tons of quartz or 42 tons of clay in 24 hr. The cost of milling is 48 cents per ton. A 5-stamp mill also ran on ore from this mine. The stamps weighed 800 lb., dropped 8 in. from 80 to 90 times a minute, and crushed 11 tons of quartz or 27 tons of clay in 24 hr. through a 1- by 5-mm. slotted screen, at a cost of 84 cents per ton. For this class of ore and these workmen, the Chilean mill is the best machine.

By reason of surface-decomposition, outcropping quartz-ledges are not common. Some remarkably rich quartz-float has been found. It occurred in clay, and was used for making brick until it was noticed to be auriferous. From 280 lb. of quartz in one boulder that was yellow with gold, 20 lb. of gold was obtained. Mr. Savitsky, who has charge of the gold-mining of the estate, considered these boulders as lying on the edge of a Tertiary sea. Some barren quartz-veins were found in the vicinity; but nothing of value was developed.

Placer gold-mining has been carried on by dredges as well as hand-labor, and vein gold-mining has been started. An account of the gold-dredging in this section is given in my paper, Gold-Dredging in the Urals.[2] At present (1907) the dredges in this section are doing fairly well. There is room on the estate for a large number of them.

In the gold-placers worked by pick and shovel, the deposits average 14 ft. in depth. The upper layer of "torf" or soft dirt

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[2] *Trans.*, xxxvii., 322 to 330 (1907).

contains little gold; the remaining 12 ft. is sand, gravel and clay, the largest stones being 6 in. long. Usually dirt is washed near the placers; but in some cases it is transported several miles by railway. The gravel is dumped on a grating with narrow openings through which it is washed by two 1.5-in. streams supplied by a Worthington pump under from 8 to 9 atmospheres pressure; the theoretical capacity of the pump being 120 cu. ft. per min. under 12 atmospheres. This washing breaks up the clay, and is said to be more effective than the ordinary Siberian machine used for the same purpose. The pebbles which collect on the grating are washed away through a trap-door, opened from time to time. The screenings flow into sluices, where the gold is collected with the aid of mercury. The estimate of costs for 1904 was 36 cents per cu. yd. for all material handled. The washing of the pay-dirt cost 13 cents per cu. yd. These costs were regarded as abnormally high. The actual costs at a placer worked some years ago were 16 cents per cu. yd. for all the material excavated, or 20 cents per cu. yd. for the pay-dirt only. (Fig. 6.)

The estimate of the yield of these placers for 1904, including the dredge, was $205,000 gold and 237 oz. of platinum.

"Starateli" or leasers, of whom there are 1,000 at work, are expected to produce $164,500 in gold, which is bought by the estate at $12.25 per ounce, its actual value being $18.60. Considerable expense is incurred in overseeing these leasers, and the profit is not so great as that secured by dredging. Moreover, some of the gold won by the leasers is sold secretly. For these reasons the number of the leasers is to be reduced.

VIII. Other Mineral Resources.

Since 1805, about 10,000 tons of chromic iron-ore have been mined on the estate, at a cost of $11 per ton, and used in the chemical works for making sodium and potassium bichromate.

Lignite beds cover many square miles of the estate. A little work has developed 3,600,000 tons. In 1903, there were mined 32,000 tons, at a cost of $0.93 per ton. As a fuel, one ton of this lignite is said to be equivalent to 0.85 cord of wood.

Manganese-ores are produced in small quantity.

IX. Copper.

Deposits of copper-ore have been found in many places on the estate. The average yield of the ores now mined is 5 per cent. It was formerly much higher.

Having devoted most of my time on the estate to the study of the copper-industry, I am able to give on that subject more abundant details, for many of which I am indebted to the kindness of Mr. N. L. Gerke, the manager of the smelting-works.

As early as 1750, this region was renowned for its deposits of copper as well as of iron. The copper-mines have been worked steadily since 1745. The copper blast-furnaces at Bogoslovsk are in a brick building erected more than 100 years ago. Copper-smelting was begun in 1765. From 1896 to 1902 the production was 9,420 tons of copper, at an average cost of 13.6 cents per lb. The works have been enlarged recently; in 1906 the product was 2,300 tons; and it is hoped to make 6,000 tons in 1907. The chief mines are at Turinske Rudnik, 8 miles from Bogoslovsk.

Geology and Mineralogy.—A geological survey of the estate, begun by Profs. Feodoroff and Nikitin, has been continued by Prof. Stratanovich, a gifted man, who was perhaps fortunate in being exiled to this region while a student in the Royal School of Mines at St. Petersburg. The following brief account of the geology is chiefly due to him.

The oldest rocks seen near the copper-mines are the Lower Devonian limestones. These have been penetrated by many eruptive rocks, the first of which were granites, aplites, and porphyries, mingled with many strata of tuffs. This complex was overlaid by "tentaculite" slate; and, still later, an eruption of augite-garnet rock broke through the whole. This augite-garnet rock was first described by Professor Feodoroff, from its occurrence here. All the copper-deposits are contact-deposits between augite-garnet and porphyry or limestone.

The chief copper-ore is chalcopyrite. Small quantities of chalcocite, bornite, native copper, cuprite, and a number of other copper-minerals are found. Pyrrhotite and pyrite are abundant; and magnetite is found in large amount in the lower levels of the Bashmakovsky mine, in which the rich copper-minerals of the upper levels have given place to pyrrhotite with 0.5 per cent. copper, and this, at still greater depth, to magnetite.

The chief non-metallic minerals are calcite, garnet, augite, and quartz.

The copper-mines now working are Bashmakovsky, Bogoslovsky, Frolovsky, Juravlinsky, Nikitinsky, and Vasilevsky. They are situated in a belt three miles in length; and although work has been carried on here for more than 140 years, there still remains a large extent of unexplored ground in the vicinity, and there are a number of promising exposures of copper-ore at other places on the estate.

The Bashmakovsky Mine.—This vein strikes a little west of north (the general strike of all the deposits), and dips 30° W. The main ore-body, now nearly worked out, was 820 ft. long, with a maximum thickness of 20 ft. and a length, on the dip, of 500 ft. This was a contact-deposit between augite-garnet and "hornblende-andesinophyr." The augite-garnet rock, from 130 to 160 ft. thick, formed the foot-wall, underlain by a feldspathic rock, 13 to 20 ft. thick, and below that, by another layer of augite-garnet. To the northwest the vein splits up and dies out; and in depth the ore changes to pyrrhotite carrying 0.5 per cent. of copper. The 375-ft. level shows a body of pyrrhotite 420 ft. long and 32 ft. thick. This ore is used for making sulphuric acid in the chemical works, where 14 of its 28 per cent. of sulphur-content is utilized. Below the 375-ft. level, the pyrrhotite contains large amounts of magnetite. On the 448-ft. level, the vein was cut off by a porphyry dike and prospecting with the diamond-drill was unavailing. A narrow vein of gold-quartz was cut on some of the levels, but has not been followed. Manganese-ore is also found here.

The Bogoslovsky Mine.—Nearly half of the copper-ore mined by the company comes from the Bogoslovsky mine. Here there are two veins, having a flat dip to the west. The augite-garnet rock occurs as two flat dikes in porphyry, interstratified with tuffs parallel to the veins. Limestone is found in blocks and also forms the foot-wall of a portion of the lower vein. The augite-garnet dikes are from 13 to 33 ft. thick, and usually 30 ft. apart; but they unite on the 210-ft. level. The "main" vein is from 3 to 20 ft. thick, the "parallel" vein somewhat thinner. The tenor of copper does not decrease with depth, as in the Bashmakovsky mine; but the ore-bodies diminish

downward. In 1904, the best ore was 70 ft. long by 140 ft. on the pitch, and 14 ft. in thickness, and its average yield was 5 per cent. of copper.

It has been very difficult to follow the ore in this mine because of the faults, both normal and reverse, which have been encountered. On one occasion, the lost vein was sought for with a diamond-drill; the cores being carefully examined by expert microscopists, who reported that the vein had not been found. Cross-cuts, subsequently run by the mine-managers, discovered the vein, and it was seen the diamond-drill had passed through it. When this was reported to the experts they re-studied their rock-sections, and found that the vein-minerals could be microscopically recognized, but that their characters had been masked by epidotization. This interesting experience shows that it is not safe for a mine-manager to rely absolutely upon petrographic conclusions, even when they are supported by high authority. I may add that I have seen elsewhere illustrations of this proposition.

The Frolovsky, Juravlinsky and Nikitinsky Mines.—In these mines, the ore occurs as a contact-deposit of steep and irregular dip between augite-garnet rock and limestone. The ore-bodies in the Frolovsky mine vary greatly in size; the largest being 200 ft. long on the pitch, with a maximum cross-section of 1,000 sq. feet.

The Vasilevsky Mine.—In this mine, the vein was well defined in the upper levels, but the formation in the lower levels is much broken up, and the ore is in bunches, though richer (8.5 per cent. of copper) than in the other mines. Surface-decomposition, which extends to the 210-ft. level in the other mines, reaches in this mine the 539-ft., or lowest, level.

According to the estimates of the engineers, there were in these mines, at the end of 1904, but 30,000 tons of ore-reserves, or one year's supply for the smelter. But the mines have been running steadily ever since, and are now producing at the rate of 100,000 tons per annum. There is a very large amount of unprospected ground on the estate, and there seems to be no reason why the mines may not be prosperous for a long time to come.

Exploitation.—One of the most remarkable features in the operation of these mines is the very slow progress made in

opening new ground. This is partly due to the extreme hardness and toughness of the augite-garnet rock; but in the softer rocks also, progress is slow. In a drift through pure crystalline limestone in the Frolovsky mine, with 2 machine-drills, and 6 men in the face for two 8-hr. shifts daily, the advance was but 25 ft. per month; and the average of a number of other drifts in the same mine was 19 ft. per month. The depth of the holes bored was 19 in. By hand-drilling, the advance in limestone drifts with 4 men, working two 8-hr. shifts daily, was 14 ft. per month. This slow advance is due to poor management, poor tools, inferior labor, and low air-pressure for the drilling-machines. It could easily be reformed. I found in Paris a responsible firm of contractors, who agreed to guarantee an advance of 200 ft. per month in limestone like the sample exhibited to them. German contractors declined to attempt the work, on account of the responsibility incurred by managers under the Russian laws. But they consider the actual rate of progress absurdly slow. R. Meyer, a German contractor of Mülheim, claims a progress for ordinary mine-drifts of 465 ft. per month in trachyte, and an average of 294 ft. for a number of months in limestone.

Mining Costs and Methods.—In the Bogoslovsk mines, the cost of drifting was $9.40 per linear foot, which compares favorably with that in other countries. That is to say, under the system of payment stated below, the economic loss due to slow progress is chiefly not of direct money-cost, but of time.

Miners are paid by contract, with a guaranteed minimum of $0.33 per diem.

Mining costs per ton of 2,000 lb. were estimated for 1904 as follows:

Bashmakovsky mine,	$8.93
Bogoslovsky mine,	5.94
Frolovsky mine,	9.01
Vasilevsky mine,	16.50

The costs per ton at the Bogoslovsky mine are classified as follows:

Pumping (average 27 cu. ft. of water per min.),	$0.96
Dead-work,	2.15
Stoping,	1.25
Timbering and filling stopes,	0.15
Tramming,	0.36
Hoisting,	0.24
Repairs,	0.05
Mine-management,	0.34
Administration (general expenses, hospitals, schools, taxes, etc.,)	0.44
	$5.94

The high pumping-costs are largely due to lack of boiler-capacity, and the use of too small and too many pumps; there being, as it were, a museum-collection of pumps at nearly every shaft. All this was well known to the local engineers; but they were unable to make needed changes, for lack of funds.

Siemens & Halske electric drills were a failure at the Vasilevsky mine. They "heated" after a few minutes' running.

Very complete plans of the mines are kept up to date by the engineer corps; in some cases horizontal plans were made for every 7 ft. in depth; but no assay-plans were made of the copper-mines.

The ore is sorted on the surface, by girls and women, in houses built for the purpose. The waste rock is seldom assayed; but it is reported to contain an average of 0.5 per cent. of copper.

There are three sorting-houses. The best has a rock-breaker, the ore from which falls over an iron grating with bars 2.5 in. apart. The screened ore falls on a grating with ⅝-in. openings; the ore remaining on each of these gratings is washed by a stream of water and hand-picked by girls, who are paid by contract and earn an average of 15 cents daily in winter and 30 cents in summer. The material passing the ⅝-in. screen is saved as ore. In 1903, the cost of sorting varied at the several mines from $0.20 to $0.56 per ton. (Fig. 7.)

By reason of the large amount of magnetic pyrites in the ore, wet concentration of it seems to be impracticable. Experiments in magnetic concentration and by the Elmore process have not yet been successful.

Metallurgical Practice.—Nearly all the ore is roasted in the

open air. At the Frolovsky mine this is done in stalls 70 ft. long by 14 ft. wide, with walls 10 ft. high, and provided with flues. No shed or roof covers the ore. Cordwood is laid down first; over this comes a layer of coarse ore; then fine ore; then a second layer of wood; then coarser ore; and then fine ore as a cover.

At the Bogoslovsky mine, the ore is roasted in both heaps (Fig. 8) and stalls. The heaps are truncated pyramids 42 by 50 ft. on the bottom and 7 ft. high, each containing 550 tons of ore. The ground is covered with coarse ore; over this are placed 12.5 cords of wood; then medium ore. The tops and sides are covered with fine ore; and cordwood is piled vertically at the four corners for chimneys. The ore is burned for from two to three weeks, then repiled and reburned for an equal time. The consumption of wood is one-seventh of the volume of the ore.

The Bogoslovsky stalls are 63 ft. long by 28 ft. wide and 7 ft. high. One layer of cordwood is used. The ore is roasted twice, the first roasting taking from four to six weeks, and the second from three to five weeks. With allowance for cooling, the operation requires from ten to twelve weeks in all. It reduces the percentage of sulphur from 20 to 6.5. The costs for 1903 were, per ton of 2,000 lb.:

Bashmakovsky mine,	$0.21
Bogoslovsky mine,	0.10
Frolovsky mine,	0.09

The stall-roasting gives the best results, and would be used exclusively, were stalls enough available.

There has been in the past much friction between the managers of the mines and of the smelting-works, with regard to the copper-content of the ore, because the sample-assays of the mines showed more copper than the smelters were willing to account for. This was partly due to the desire of each department to show as good results as possible. In former years, the difference was sometimes enormous. For example, the mine-assays for a year showed an average of 7 per cent. of copper, while the smelter-assays gave only 4.81 per cent. Such controversies between the different departments of enterprises under one ownership have not been unknown elsewhere.

At Bogoslovsk, the question of sampling was thoroughly in-

vestigated, and the chief chemist, Mr. E. Juon, made a report on the losses in smelting and the differences in assaying in 1902, which was in part published in the *Österreichische Zeitschrift für Berg-und Hüttenwesen.* After that report, the difference decreased greatly. In 1903 the mine-assays gave 5.49, and the smelter-assays 4.81 per cent. The introduction of mechanical sampling was thought too expensive by the management, but would have probably been a good investment.

Mr. Juon found that the (roasted) ore was carefully sampled at the mines; that there was some loss in dust; that the copper-contents of the ore were determined at the smelter from the assay and weights of the matte and slags, the amount of copper in these two products being taken as the amount received by the smelters. A careful study of 12 days at one furnace showed the amount of copper in the slag, matte, and other smelting-products to be 3.72 per cent. less than in the material fed into the furnace, which loss of 3.72 per cent. must be accounted for by the flue-dust and by volatilization. A similar study of the Bessemer converter showed a loss of 11.26 per cent. of copper, chiefly in dust, which was produced in excessive quantities by the nearly vertical blowing of the tuyeres. Samples from the roof of the smelting-house assayed 70 per cent. in copper, and showed globules of copper 0.1 in. in diameter. After this investigation, a flue ending in a brick chamber 36 ft. long by 27 ft. wide and 13 ft. high, and connecting with a stack 125 ft. high, was built, and the loss was greatly reduced. The loss in refining was found by Mr. Juon to be 1.98 per cent.; but this result is doubted by the metallurgical officials.

At present, the ore is carefully sampled by hand-shoveling, both at the mines and at the smelter, and I am convinced that part of the remaining difference of 0.68 (5.49–4.81) per cent., between the mines and the smelter is a real loss, due in part to the leaching of the roasted ore by rains (the rainfall is 15 in.) and partly to loss in dust. No doubt there is a remainder, the cause of which may be called "psychological"). The question of losses due to leaching by the rain caused trouble at Ducktown, Tenn., as Dr. Peters relates in his valuable work on the metallurgy of copper.

Copper-smelting was begun in Bogoslovsk in 1765, in which year 722 tons were worked. Water-power supplemented by

steam is used, the furnaces taking 40 h.p., the converters 130 horse-power.

In August, 1904, there were: four Pilz furnaces 48 in. in diameter, each having a daily capacity of 18 tons; three Raschette furnaces, one, 144 by 42 in., daily capacity 54 tons, and two, 65 by 42 in., daily capacity 14 tons each. The annual capacity was 36,000 tons of ore. Since then the smelter has been enlarged. A furnace 375 by 42 in. in size has been built; and it is hoped to smelt over 100,000 tons of ore for 6,000 tons of copper for 1907.

The furnaces are of local brick. Charcoal is used for fuel, and up to 1906 it had been found too soft to use in a water-jacket furnace with high blast-pressure. In 1905, the pressure was 160 mm. of water (3.75 oz. per sq. in.).

The ordinary furnace-charge is:

Bogoslovsk mine ores,	36,000 lb.
Custom-ores,	1,800 lb.
Slags,	3,600 lb.
Burnt lime,	1,800 lb.

In 1903, the smelter treated 28,476 tons of Bogoslovsk ores, 593 of custom ores, 1,133 of soil from the smelter-yard, and 265 of converter-slag. The product was 5,071 tons of matte, making 1,445 tons of blister copper, or 1,374 tons of refined copper.

The matte and slag run continuously into a fore-hearth; the slag overflowing into running water, whence it is shoveled into railway-cars and taken away to be used as railway-ballast. The matte is intermittently tapped, in 2-ton charges, into a clay-lined pot mounted on wheels and hauled by a horse to a horse-capstan, which hoists the pot to the converter-floor. The smelting-costs per ton (2,000 lb.) of ore were in 1903: Labor, $0.44; charcoal, $1.16; repairs and supplies, $0.52; total, $2.12.

The laborers are paid on a complicated system, the growth of more than a century. The furnace-men get 14 cents per ton or, for an average day, $3.25, divided among 2 furnace-men and 4 helpers. Charcoal to the amount of 24.33 per cent. of the weight of the charge is allowed, and 18 per cent. of the value of the charcoal saved on this basis is paid as a premium. The

actual proportion of charcoal used is about 23 per cent. The other employees are paid on similar systems. Day laborers receive from 25 to 30 cents daily.

The matte varies in copper from 18 to 50 per cent. In 1903, it averaged 27.11 per cent. There is no trouble in keeping the low-grade matte liquid during its ten minutes' passage to the converters; but the 40 to 50 per cent. matte gives trouble by chilling.

There are eight converters, two of which are in blast at a time. They were introduced in 1885, and represent the Manhès converter, considerably modified to avoid paying a royalty. This was a mistake; for the upward-blowing tuyeres occasion a very large loss in copper. The blast-pressure is 280 mm. of mercury (87 oz. per sq. in.).

The converter shells, 6 ft. in diameter, are lined with a mixture of 80 per cent. of quartz and 20 per cent. of clay—the latter carrying some coarse quartz. For each pound of copper made, 1.2 lb. of lining is consumed. The lining is put in as soon as the shell cools down to 170° F., this being the maximum temperature the workmen will endure. The lining is 1 ft. thick, so that the newly-lined converter has an inside diameter of 4 ft.

An ideal heat would be: 3,600 lb. matte charged in converter; blast for 40 min.; 3,600 lb. of slag poured off, leaving in the converter 1,440 lb. of white metal containing 70 per cent. of copper, to which a new charge of 3,600 lb. of matte is added; blast for 40 min.; 3,600 lb. of slag poured off, leaving in the converter 2,880 lb. of white metal; blast for one hour; 1,800 lb. of blister copper poured.

The converter has thus received 7,200 lb. of 30-per cent. matte, containing, roughly, 2,160 lb. of copper, and has given: 7,200 lb. of slag with 2.4 per cent. of copper (173 lb. of copper); 360 lb. of flue-dust, 70 per cent. of copper (252 lb. of copper); 1,800 lb. of blister copper, 96.4 per cent. of copper (1,735 lb. of copper), giving a total of 9,360 lb. of material treated containing 2,160 lb. of copper.

There is a gain in weight of 9,360 — 7,200 = 2,160 lb. This comes from the lining, of which 1,624 tons were consumed in 1903 to make 1,374 tons of copper. The notable features in this converting are the low grade of the matte (at times con-

taining but 18 per cent. of copper) and the great consumption of lining.

Two heats are made to each relining of the converter; one lining suffices for the conversion of 14,000 lb. of matte. The above ideal heat is rarely attained in practice. Much white metal goes into the slag, which is poured into large iron pots, and, after breaking up, is sorted into white metal (which is melted in small reverberatory furnaces), clean slag containing 0.3 per cent. of copper (which goes on the dump), and foul slag (which goes to the blast-furnace). In 1903, the product of blister copper was 1,445 tons, which averaged 98 per cent. of copper, and was refined in reverberatory furnaces. Electric refining has been tried and abandoned once, but is to be tried again.

In 1903, the converting cost per 2,000 lb. of matte:

Repairs,	$0.90
Wood,	0.82
Labor,	1.35
Supplies,	0.70
Power,	0.38
Total,	$4.15

The refined copper is cast in 28-lb. ingots. The cost of refining the blister copper is $4 per ton.

The total costs for 1903 were:

	Per 2,000 Lb. of Ore.	Per Pound of Copper. Cents.
Mining, sorting and roasting,	$8.59	9.06
Matte-smelting,	2.12	2.20
Refining,	0.20	0.21
Converting,	0.89	0.92
Management,	0.33	0.34
Administration,	0.95	1.05
	$13.08	13.78

Comparison with costs in the United States shows that the high cost of the Bogoslovsk copper is due to mining mainly. The management and administration costs are also high,—the latter necessarily so, by reason of legal requirements, which oblige the estate to do work elsewhere done by county and State governments.

Stevens[1] gives the total costs at Anaconda, Mont., as $9.36 per ton of ore, and the costs of the Tennessee Copper Co. at Ducktown, Tenn., as follows:

[1] *Copper Hand-Book* for 1907.

Mining,	$0.686
Development,	0.171
Crushing and sorting,	0.106
Transportation,	0.128
Matte-smelting,	1.24
Converting,	0.2313
Sundry,	0.208
	$2.7703

This copper was not refined. Considering the small quantity of ore handled by the Bogoslovsk estate, the smelting-costs do not seem high, and they will be considerably reduced in the enlarged plant, now in operation.

X. Analyses.

The following analyses of the copper-ores and products will be found interesting:

Analyses of Copper-Ores.

	SiO_2.	Al_2O_3.	Fe.	Cu.	S.	CaO.	MgO.	Mn.
Bashmakovsky, average for 1901, raw ore,	31.52	1.93	24.96	4.87	18.64	14.18	2.60	0.66
Nikitinsky raw ore,	37.68	2.14	20.96	3.64	14.43	20.22	......	0.49
Frolovsky raw ore,	33.22	1.11	16.03	7.04	15.82	22.23	4.10	0.46
Bogoslovsky raw ore,	29.08	3.13	23.10	5.87	25.30	9.76	3.21	0.32
Vasilevsky raw ore,	38.15	7.53	18.52	10.19	14.86	8.09	2.17	......
Roasted ores, Bogoslovsky, 1st class,	27.94	7.52	23.54	4.02	5.4	10.35	4.78	......
Bogoslovsky, 2d class,	31.96	8.16	22.54	2.39	5.8	11.58	2.16	......
Frolovsky,	26.59	0.95	16.54	5.45	5.3	24.24	7.81	......
Bashmakovsky,	25.14	7.95	20.90	5.04	6.0	16.78	2.90	......
General average, June–Dec., 1903,	27.07	6.82	21.82	5.53	6.57	14.39	1.59	......
Slag from ore-smelting,	41.10	5.11	18.22	0.12	0.10	15.65	......	......

Analyses of Matte and Refined Copper.

	Matte. Per Cent.	Refined Copper. Per Cent.
Copper,	31.26	99.66
Iron,	38.91	0.021
Sulphur,	26.69	0.014
Cobalt,	0.51	......
Nickel,	0.028	0.052
Arsenic and antimony,	trace	0.049
Bismuth,	0.00	0.000
Silver,	0.006	0.040
Lead,	0.008	0.005
Silica,	0.016	0.030 (Tin oxide and silica).
CaO,	0.68	trace of gold.
MgO,	0.12	

XI. Russian Weights, Measures and Money.

I have encountered much difficulty in getting correct equivalents for Russian weights and measures. Their system is as absurd as our own, and makes one long for the day when the metric system shall replace all others.

Some of the values given below have been taken from the *Transactions of the Institution of Mining and Metallurgy*,[4] where they are given in a paper by A. L. Simon on Siberian Mines and Mining Conditions, and the discussion thereof by Dr. F. H. Hatch, who furnished more accurate determinations of several values.

Weights.

One pood = 40 funt (Pfund) = 3,840 zolotniks = doli 368,640.
= 36.112808327 avoirdupois pounds.
= 526.6451214 Troy ounces.
= 16.3804964 kilograms.
One pood of pure gold = 21,157.025 rubles.
= $10,886.718.
One funt = 96 zolotniks = 9,216 doli.
= 409.51241 grams.
= 13.166128 Troy ounces.
= 0.902820208 avoirdupois pound.
One funt of pure gold = $272.17.
One zolotnik = 96 doli.
= 0.1371471 Troy ounce.
= 4.26575 grams.
One zolotnik of pure gold = $2.83508.
One dolya = 0.0014286 Troy ounce.
= 0.0444349 gram.
One dolya of pure gold = $0.029532.
One 2,240-lb. ton = 62.02783 poods.
One 2,000-lb. ton = 55.38201 poods.
One pood = 0.0180564 ton of 2,000 lb.
One ton (2,000 lb.) of pure gold = $602,928.375.
One Troy ounce of pure gold = $20.67183.
One ruble = $0.514567.

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[4] Vol. xvi., pp. 358, 382 (1907).

According to the British "mint parity value" of 25.375 pence, given by Dr. Hatch, and taking the value of the Troy ounce of gold as £4 4s. 11.454d., and the value of the pound sterling as \$4.866565, the gold ruble would be worth \$0.514538.

The value I have given above was calculated from the statement on the 10-ruble gold coin, that it contains 1 zolotnik and 78.24 doli of gold. The difference of \$0.000029 between the two results is of no practical importance.

I would call attention here to several values in the above statement, which are carried to many places of decimals. These have been quoted from Dr. Hatch; but I cannot forbear to point out that they present, in my judgment, a misleading appearance of minute accuracy. For example, the pood is said to be equal to 36.112808327 lb. avoirdupois. Now, the most accurate weighing of our chemical balances will probably determine 1 gramme to within one five-hundredth part of a milligramme, or 0.000002 g.; that is to say, it would leave the sixth decimal in doubt. It is very easy, of course, to carry out a quotient in division to any number of decimals; but when neither divisor nor dividend can possibly be accurate beyond five places, spinning out the quotient to eleven places is neither scientific nor significant. All that can be truly said concerning Dr. Hatch's pood is that it is equal to 36.11281 lb., with some doubt as to the last decimal figure, and that the addition of six, or sixty, further figures would not in any degree affect that doubt. The same criticism applies to the data upon which his calculation was founded, such as the solemn official declaration by the International Bureau of Weights and Measures that 1 lb. avoirdupois = 0.4535924277 k., in which result the last digit represents so many ten-thousandths of a milligramme! Since this result is the quotient from two magnitudes, neither of which could be accurately determined within two-thousandths of a milligramme, it must be regarded as a case of very "long division," and nothing more!

Values Per Cubic Unit.

One ruble per cubic sagene	= \$0.04053 per cu. yd.
One ruble per pood	= \$28.50 per 2,000-lb. ton.
	= \$0.01425 per lb.

Values Per Unit of Weight.

Zolotniks Per 100 Poods.	Equivalent in U. S. Money Per Ton of 2,000 Lb.	Doli Per 100 Poods.	Equivalent in Cents Per Ton of 2,000 Lb.
1,	$1.57	1,	1.64
2,	3.14	2,	3.27
3,	4.71	3,	4.91
4,	6.28	4,	6.54
5,	7.85	5,	8.18
6,	9.42	6.	9.81
7,	10.99	7,	11.45
8,	12.56	8,	13.08
9,	14.13	9,	14.72
10,	15.701	10,	16.355

Lengths and Distances.

One verst = 500 sagenes = 3,500 ft. (The Russian and the English foot are equal.)
= 0.6628786 mile.
= 1.0668 kilometers.
One sagene = 7 ft. = 3 archines.
= 2.1336 meters.
One archine = 16 vershoks.
= 2 ft. 4 in.
= 0.7112 meter.
One vershok = 1.75 in. (The Russian and the English inch are equal.)
= 0.04445 meter.

Areas.

One square verst = 281.2213 acres.
= 0.4394 sq. mile.
= 113.80 hectares.
One dessiatine = 2,400 sq. sagenes.
= 2.6997 acres.
= 1.09252 hectares.
One square sagene = 5.4444 sq. yards.
= 4.55217 sq. meters.

Volumes.

One cubic sagene = 343 cu. ft.
= 12.704 cu. yards.
= 2.68 cords.
= 9.71242 cu. meters.
One chetverik = 26.24 liters.
One vedro = 12.30 liters.

The following illustrations, Figs. 1 to 8, engraved from photographs taken by me, although they may have no special professional value, will serve to give to those who have never visited this part of Russia a notion of the scenery, and of the people who have been for more than a century engaged in developing and utilizing the mineral wealth of an almost unknown corner of the world.

FIG. 1.—HOUSE OF GENERAL MANAGER, BOGOSLOVSK ESTATE.

FIG. 2.—BOGOSLOVSK, SEEN FROM SMELTER.

FIG. 3.—MINING STUDENTS.

FIG. 4.—IRON BLAST-FURNACE AT NADESDA.

FIG. 5.—HAULING IRON-ORE FROM AUERBACH MINE.

FIG. 6.—STARATELI, WORKING A PLACER.

ORE-SORTER, BASKMAKOVSKI MINE.

FIG. 8.—HEAP-ROASTING, BOGOSLOVSK MINE.

The Uniform Nomenclature of Iron and Steel.

Report of Committee 24, of the International Association for Testing Materials, presented at the Brussels Congress, 1906. Republished for use at the 94th Meeting of the American Institute of Mining Engineers, New York, N. Y., February, 1908. Discussion by letter is requested by the Secretary of the Institute.

The Committee appointed for the solution of Problem 24 consisted of the following members:

Prof. H. M. Howe, New York, N. Y. (*Chairman*); L. Lévy, Paris, France (*Vice-Chairman*); Prof. D. Tschernoff, St. Petersburg, Russia (*Vice-Chairman*); Prof. Albert Sauveur, Cambridge, Mass. (*Secretary*); Van Drunen, Ixelles, Belgium; Lieut.-Col. H. Tusen, Copenhagen, Denmark; E. P. Martin, Abergavenny, England; A. Pourcel, Paris, France; H. Brauer, Dortmund, Germany; Dr. Prof. H. Wedding, Berlin, Germany; P. Verole, Milan, Italy; A. Baalsrud, Christiania, Norway; A. R. v. Dormus, Vienna, Austria; A. Sailler, Vienna, Austria; Bureau des Forges, St. Petersburg, Russia; Prof. N. Belelubsky, St. Petersburg, Russia; N. Jossa, St. Petersburg, Russia; Maj.-Gen. M. Korobkoff, St. Petersburg, Russia; S. Smirnoff, St. Petersburg, Russia; Ladislaus v. Tetmajer, Budapest, Hungary; H. H. Campbell, Steelton, Pa.

Early in February, 1905, a list of species and varieties of iron and steel, with definitions, drawn by the Chairman and Secretary of Committee 24, was sent to every member of this Committee with a request for comments and suggestions. A special request was sent to the following gentlemen for the equivalents in their several languages of these species and varieties: A. Pourcel, Paris, France; Prof. H. Wedding, Berlin, Germany; J. A. Brinell, Stockholm, Sweden; Prof. H. I. Hannover, Copenhagen, Denmark; Prof. P. Kley, Delft, Holland; P. Verole, Milan, Italy; Col. Cubillo, Trubia, Spain.

This present report, which is based upon our original list and definitions, and upon the replies to these requests, consists of four parts:

I. A polyglot, which gives the names of the chief classes of iron and steel in English, French, German, Swedish, Danish and Dutch. We regret that we have failed to get the Italian and Spanish names.

II. English definitions of principal classes of iron and steel.

III. A glossary of special sizes and shapes of iron and steel.

IV. A note on the boundary between steel and cast-iron.

I. Polyglot, in English, French, German, Swedish, Danish and Dutch, of the Chief Classes of Iron and Steel, and of the Apparatus in which They are Made.

This list is not intended to be complete, but rather to include only those varieties which are of interest to the Association.

Names.					
English.	French.	German.	Swedish.	Danish.	Dutch.
Species.					
Cast-iron.	Fonte.	Roheisen if not remelted, Guszeisen if remelted.	Gjutjern.	Stobejaern.	Gietyzer (ruwyzer).
Varieties.					
White cast-iron or pig-iron.	Fonte blanche.	Weiszes Roheisen.	Hvitt tackjern.	Hvidtjaern.	Witgietyzer (witruwyzer).
Gray cast-iron or pig-iron.	Fonte grise.	Graues Roheisen.	Grått tackjern.	Graatjaern.	Grysyzer.
Mottled cast-iron or pig-iron.	Fonte truitée.	....	Hagelstatt or Halfhwitt or halfgratt tackjern.	Spragletjaern.	Wit korreligyzer.
Pig-iron (white, gray, mottled, etc.)	Gueuses de fonte ou fonte en gueuse.	Guszeisen.	Tackjern.	Pigjaern or Raajaern.	....
Hot metal, or direct metal.	Fonte de première fusion?	Remeisen.	Direct gjutet fran Masugnen.	Smeltet Raajaern.	No equivalents.
Basic cast-iron or pig-iron.	....	....	....	....	
Hematite cast-iron or pig-iron.	....	....	....	....	
Malleable pig-iron.	....	....	....	....	
Washed metal.	Fonte épurée.	....	Tvattad.	No equivalent.	
Refined cast-iron.	Fonte mazée.	....	Raffineradtjern.	Raffineret Raajaern.	
Charcoal-hearth cast-iron.	Fonte mazée.	Herdfrischeisen.	No equivalent.	Raffinere Raajaern.	
Alloy cast-iron.	Fontes spéciales.	....	Special tackjern.	No equivalent, perhaps Special raajaern.	
Species.					
Malleable castings.	Fonte malléable.	Schmiedbares Guszeisen or Schmiedbarer Gusz.	Aduceradtjern.	Hammerbart Stöbejaern.	....

Apparatus in which Usually Made.					
English.	French.	German.	Swedish.	Danish.	Dutch.
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
Blast-furnace.	Haut fourneau.	Hochofen.	Masugn.	....	....
....	....	....	....	....	....
Pernot-furnace.	Four Pernot.	....	Pernot's ugn.	....	....
Coke-refinery.	Feu de finerie anglais.	Feinherd or Feinofen.	Koksraffineringsverk.	....	....
Charcoal-hearth.	....	Frischherd.	Fräkolshärd.	....	....
Blast-furnace, crucible- or electric-furnace.	Haut fourneau, four à creusets, four électrique.	....	Masugn, degel, Elektrisk ugn.	....	....
Air-furnace, open-hearth furnace or cupola-furnace, followed by long annealing in boxes heated externally.	Four à Réverbère, four Siemens, cubilot.	....	Reverberugn, Martinsugn, Kupolugn.	....	....

English.	French.	German.	Swedish.	Danish.	Dutch.
Species.					
Steel.	Acier.	Stahl.	Stål.	Staal.	Staal.
Variety A.					
Called steel because cast initially into a malleable mass. 1. Soft or low-carbon steel, or ingot-iron.	Acicr doux, acier extra doux, fer fondu.	Fluszeisen.[9]	Götmetall.	Staal, Blodtstaal.	Smeltyzer.
2. Half-hard and hard or medium and high-carbon steel, or ingot-steel.	Acier fondu, acier mi-dur, acier dur.	Flusztahl.[9]	....	Haardstaal.	....
Sub-Varieties.					
Bessemer steel.	Acier Bessemer.	Bessemer-Fluszeisen, Bessemer-Fluszstahl.	Bessemerstål.	Bessemer staal.	Bessemer staal.
Open-hearth steel.	Acier Martin Siemens, acier sur sole.	Flammofen-Fluszeisen, Flammofen-Fluszstahl.	Martinstål.	Martinstaal.	Frischstaal.
Crucible-steel.	Acier au creuset.	Tiegelfluszeisen, Tiegelfluszstahl.	Degelstål or Degelgjutstål.	Digelstaal.	Kroerenstaal.
Cast-steel.	Acier au creuset.	Guszstahl.	Gjutstål.	Stobestaal.	Gietstaal.
Steel castings.	Moulages d'acier.	Fluszwaren.	Stålgjutgods.	Staal-stöbegods, or Facongods.	....
Variety B.					
Weld-steel, or wrought-steel, called steel because it is capable of hardening greatly by sudden cooling.	Fer fort ou fer dur.	Schweiszstahl or Schweiszeisen.[9]	Wäll stål rarely used, no equivalent.	Svejsestaal.	Welyzer.
Sub-Varieties.					
Blister-steel, also called cemented- and converted-steel.	Acier poule, acier cémenté, acier de cèmentation.	....	Blåsstål, Bräunstål, Cementstål.	Blaerestaal or Cementstaal.	No equivalent. cementstaal.
Shear-steel.	Acier rafiné une fois corroyé.	....	....	....	No equivalent.
Puddled-steel.	Acier puddlé.	Puddelstahl	Puddelstål.	Puddelstaal.	Puddelstaal.
Variety C.					
Alloy-steels.	Alliages à base de fer, aciers spéciaux.	Sonderstahl.	Special stål.	No equivalent, perhaps Special staal.	No equivalent.
Species.					
Wrought-iron (or weld-iron, or, in Great Britain, malleable iron.)	Fer soudé.	Schmiedeeisen and Stabeisen.	Smidesjern, Lancashire jern.	Svejsejaern.	Welyzer.
Varieties.					
Puddled-iron.	Fer puddlé.	Puddeleisen	Puddeljern.	Puddeljaern.	Puddelyzer.
Bloomary- or knobbled-iron.	Fer au bois (obtenu au Bas-Foyer).	....	Lancashire, Franche-Comté or Walloonjern.	Haerd frisket jaern (always refers to Lancashire iron from Sweden).	....

[9] According to Wedding, cast metal having a tenacity greater than 50 kg. per sq. mm. should be called Fluszstahl, while with a smaller tenacity it should be called Fluszeisen. Weld metal with a tenacity exceeding 42 kg. per sq. mm. should be called Schweiszstahl and with a less tenacity, Schweiszeisen.

Apparatus in Which Usually Made.

English.	French.	German.	Swedish.	Danish.	Dutch.
Bessemer converter, open-hearth furnace or crucible-furnace.	Convertisseur Bessemer, four Siemens, four à creusets.	Bessemer Birne, Flusseisen-Flammofen, Tiegelofen.	Bessemer converter, martinsugn, degelstålsugn.	....	....
....	....	....	....	....	....
Bessemer converter.	Convertisseur Bessemer.	Bessemer Birne.	Bessemer converter.	....	....
Open-hearth furnace.	Four Siemens.	Flammofen (Martin- or Siemens-ofen).	Martinsugn.	....	....
Crucible-furnace.	Four à creusets.	Tiegelofen.	Degelståls-ugn.	....	....
Crucible-furnace.	Four à creusets.	Tiegelofen.	Degelstals-ugn.	....	....
....	....	....	....	....	....
....	....	....	....	....	....
Cementation-furnace.	Four de cémentation.	....	Bräunståls-ugn.	....	....
....	....	....	....	....	....
Puddling-furnace.	Four à Puddler.	Puddel-ofen.	Puddelugn.	....	....
Bessemer converter, open-hearth furnace, crucible-furnace.	Convertisseur Bessemer, four Siemens, four à creusets.	....	Bessemer converter, martinsugn, degelståls-ugn.	....	....
Puddling-Furnace.	Four à Puddler.	....	Puddelugn.	....	....
....	....	....	....	....	....
Bloomary, called also low hearth, charcoal-hearth, Lancashire hearth, knobbling-fire, etc.	Bas-Foyer, feu d'affinerie.	....	Lancashire-härd,[10] Franche-Comté-härd, Wallonhård.[11]	....	....

[10] Used in Dannemora district in Sweden exclusively for producing bars to be cemented and melted in crucible furnaces (Brinell).

[11] Fired with charcoal and used in Sweden to a great extent (Brinell).

II. Definitions.

Alloy Cast-Irons, those which owe their properties chiefly to the presence of an element (or elements) other than carbon.

Alloy Steels, those which owe their properties chiefly to the presence of an element (or elements) other than carbon.

Basic Pig-Iron. In America, pig-iron containing so little silicon and sulphur that it is suited for easy conversion into steel by the basic open-hearth process. It is restricted to pig-iron containing not more than 1.00 per cent. of silicon.

Bessemer Pig-Iron, that which contains so little phosphorus and sulphur that it can be used by itself for conversion into steel by the original or acid Bessemer process. In America this term is restricted to pig-iron containing not more than 0.10 per cent. of phosphorus.

Bessemer Steel, steel made by the Bessemer process, whether its carbon-content is high, low or intermediate.

Blister-Steel, steel made by carburizing wrought-iron by heating it in contact with carbonaceous matter. It might also be made by so carburizing a low-carbon steel.

Cast-Iron. Generically, iron containing so much carbon or its equivalent that it is not malleable at any temperature. Specifically, cast-iron in the form of castings other than pigs, or remelted cast-iron suitable for casting into such castings, as distinguished from pig-iron, *i. e.*, cast-iron in pigs, etc. (See Pig-Iron.) For instance, cast-iron pigs, *i. e.*, pig-iron, like lead in pigs, *i. e.*, pig-lead, is remelted and cast into castings, such as columns, locks, gears, etc., of special shape, suited to their special purpose; these are specifically called "cast-iron," and this is the usual restricted meaning of "cast-iron" in trade language.

When we say "the fracture and density are those of cast-iron," "the right-hand side of Roberts-Austen's diagram represents cast-iron," or "Production of Steel by the Partial Decarburization of Cast-Iron" (Percy, *Iron and Steel*, xv.), we use "cast-iron" in its generic sense, including both pig-iron in pigs and cast-iron in other and shaped castings, whether these are made direct from the molten pig-iron running from the blast-furnace, or by remelting that cast-iron. On the other hand, when we say "cast-iron locks, posts, and other hardware," we use "cast-iron" in its specific sense of "shaped castings of cast-iron," and we exclude pig-iron. Exactly in the same way when we say "all men must die" or "the cavalry lacks horses," we use "man" and "horse" generically to include women and mares; when we say "the men are at the war" or "the horses beget colts," we use "man" and "horse"

specifically, and exclude women and mares. The meaning of "pig-iron," "woman" and "mare" is never in doubt; in which of its two meanings a word like "cast-iron," "man" or "horse" is to be taken should be and generally is indicated clearly by the context. Dual meanings might conceivably lead to confusion, but in fact they do not; probably no reader of these present lines has ever been confused, unless intentionally, as to the meaning of "horse" or "man," nor need he be as to the meaning of "cast-iron." Were your Committee inventing language, it would avoid dual meanings; as our function is not to invent but to record existing language, we have no jurisdiction over the meanings of these words. We only assert our knowledge that the generic sense of "cast-iron" is so firmly established in English literature that it cannot and should not be changed. That the trade itself rarely has occasion to make use of the generic meaning of cast-iron would not warrant a vain attempt to root that established meaning out of scientific and literary usage. The trade need never use the generic meaning of "cast-iron." The truth is that science and letters often need generic terms which trade does not need; "mollusk" is needless to the fish trade, "mammal" is needless to the circus trade, "conifer" is needless to the lumber trade; nevertheless, those words and that sense will remain, because they are needed elsewhere.

The Committee recommends drawing the line between cast-iron and steel at 2.20 per cent. of carbon for the reason that this appears from the results of Carpenter and Keeling to be the critical percentage of carbon corresponding to the point "a" in the diagrams of Roberts-Austen and Roozeboom. As to the signification of this critical point the Committee is not prepared to express an opinion.[1]

Cast-Steel, the same as crucible-steel. Obsolescent, and to be avoided because confusing and because a temptation to fraud.

Cemented-Steel, the same as blister-steel.

Charcoal-Hearth Cast-Iron, cast-iron which has had its silicon and usually its phosphorus removed in the charcoal-hearth, but still contains so much carbon as to be distinctly cast-iron.

Converted-Steel, the same as blister-steel.

Crucible-Steel, steel made by the crucible-process, whether its carbon-content is high, low or intermediate.

Gray Pig-Iron and Gray Cast-Iron, pig-iron and cast-iron in

[1] Professor Wedding reports that in Germany every metallic product of the blast-furnace is called pig-iron or cast-iron, and appears to dissent from drawing any line between cast-iron and steel. Mr. Brinell thinks that 2.20 per cent. of carbon is a rather high limit for practical purposes.

the fracture of which the iron itself is nearly or quite concealed by graphite, so that the fracture has the gray color of graphite.

Hematite Pig-Iron, originally pig-iron made from the hematite-ores of England, which happen to be so free from phosphorus and sulphur that the pig-iron made from them can be used by itself for the acid Bessemer process. By association it has come to mean any pig-iron thus relatively free from phosphorus and sulphur. The term is not used in America, and is undesirable.

Hot Metal or Direct Metal, the molten cast-iron from the blast-furnace before it has been allowed to solidify.

Ingot-Iron,[2] steel cast into an initially malleable mass and containing so little carbon or its equivalent that it does not harden greatly on sudden cooling. The word is rarely used in English, "mild steel" or "low-carbon steel" or "soft steel" being generally used in its place. In America the line between soft steel and half-hard steel is usually drawn at a carbon-content of about 0.20 per cent.

Ingot-Steel,[3] steel cast into an initially malleable mass and containing so much carbon or its equivalent that it hardens greatly on sudden cooling. The word is rarely used in English, but "hard steel," "high-carbon steel" or "half-hard steel" are used in its place.

Malleable Castings, castings of malleable cast-iron, which see.

Malleable Cast-Iron, iron which when first made is cast in the condition of cast-iron, and is made malleable by subsequent treatment without fusion.

Although the English name of this variety suggests that it is cast-iron, it is not truly a variety of cast-iron, but rather forms an independent species of iron, because it lacks the essential property of cast-iron, viz., its extreme brittleness. Though the term "malleable castings" is very common, the term "malleable cast-iron" is very rarely used. The common but inexcusable term we regret to say is "malleable," pronounced "mallable," used as a substantive. Those with some respect for their mother tongue, if asked of what material a malleable casting was composed, would generally use a circumlocution.

Malleable Iron, the same as wrought-iron. Used in Great Britain, but not in the United States, except carelessly as meaning "malleable cast-iron" (vulgar, "malleable").

Malleable Pig-Iron, an American trade-name for the pig-

[2] This expression is not used in Denmark, where the nomenclature proposed in Philadelphia (1876) has never been accepted (Hannover).

[3] This expression is not used in Denmark (Hannover).

iron suitable for converting into malleable castings through the process of melting, treating when molten, casting in a brittle state, and then making malleable without remelting. The term should be used with care to avoid confusion. This material is also called in trade in America "malleable iron," but this use should be avoided, because "malleable iron" has the older and (in Great Britain) firmly established meaning of "wrought-iron."

Mottled Pig-Iron and Mottled Cast-Iron, pig-iron and cast-iron the structure of which is mottled, with white parts in which no graphite is seen, and gray parts in which graphite is seen.

Open-Hearth Steel, steel made by the open-hearth process, whether its carbon-content is high, low or intermediate.

Pig-Iron, cast-iron which has been cast into pigs direct from the blast-furnace. This name is also applied to molten cast-iron which is about to be so cast into pigs or is in a condition in which it could readily be cast into pigs.[4]

Plate-Iron, a name applied in Great Britain to refined cast-iron.

Puddled-Iron, wrought-iron made by the puddling-process.

Puddled-Steel, steel made by the puddling-process, and necessarily slag-bearing. (See Weld-Steel.)

Refined Cast-Iron, cast-iron which has had most of its silicon removed in the refinery-furnace, but still contains so much carbon as to be distinctly cast-iron.

Shear-Steel, steel, usually in the form of bars, made from blister-steel by shearing it into short lengths, piling, and welding these by rolling or hammering them at a welding-heat. If this process of shearing, piling, etc., is repeated, the product is called "double-shear steel."

Steel, iron which is malleable at least in some one range of temperature, and in addition is either (*A*) cast into an initially malleable mass; or (*B*) is capable of hardening greatly by sudden cooling; or (*C*) is both so cast and so capable of hardening. Variety *A* includes also molten iron which, if cast, would be malleable, as do its two sub-varieties, "ingot-iron" and "ingot-steel." (Tungsten-steel is malleable only when red-hot.)

Steel-Cast (adjective), consisting of solid Bessemer, open-hearth, crucible- or other slagless steel, and neither forged nor rolled: applied to steel-castings. For instance, a "steel-cast" gun is a gun which is a steel-casting, *i.e.*, which has been neither forged nor rolled. To call it a "cast-steel" gun would imply

[4] Molten cast-iron is not in Denmark called pig-iron (Pigjaern), Hannover.

that it was made of crucible-steel, to which the term "cast-steel" is restricted.

Steel Castings, unforged and unrolled castings made of Bessemer, open-hearth, crucible- or any other steel. Ingots and pigs are in a sense castings; the term "steel castings" is used in a more restricted sense, excluding ingots and pigs and including only specially shaped castings, such as are generally used without forging or rolling. They may, however, later be forged, *e.g.*, under the drop-press, when they cease to be "castings" and become "drop-forgings," or if only part is forged then they are partly forgings and partly castings.

Washed Metal, cast-iron from which most of the silicon and phosphorus have been removed by the Bell-Krupp process without removing much of the carbon, so that it still contains enough carbon to be classed as cast-iron. The name "washed metal" is extended to cover this product even if its carbon is somewhat below the proper limit for cast-iron.[5]

Weld-Iron, the same as wrought-iron. Obsolescent and needless.

Weld-Steel, iron containing sufficient carbon to be capable of hardening greatly by sudden cooling, and in addition slag-bearing, because made by welding together pasty particles of metal in a bath of slag, as in puddling, and not later freed from that slag by melting. The term is rarely used.

White Pig-Iron, and White Cast-Iron, pig-iron and cast-iron, in the fracture of which little or no graphite is visible, so that their fracture is silvery and white.[6]

Wrought-Iron, slag-bearing, malleable iron, which does not harden materially when suddenly cooled.

Wrought-Steel, the same as weld-steel. Rarely used.

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[5] Unknown in Denmark, no equivalent (Hannover).

[6] Professor Wedding reports that the term "white pig-iron" is applied in Germany to certain varieties of pig-iron which, instead of being silvery and white, are dark. The President and Secretary do not feel confident as to Professor Wedding's meaning.

III. Glossary of Special Sizes, Shapes and Conditions of Iron and Steel.

Names designating special sizes or shapes of iron and steel.

English.	French.	German.	Swedish.
Bar-Iron, wrought-iron in the form of bars, rods, etc.	....	Stabeisen.	
Muck-Bar, the rough bars, usually 1 in. thick and about 4 in. wide, made by the first rolling of a ball of puddled-iron.	Loupe, Lopin, Ebauché de puddlage, Fer brut.		No equivalent.
Merchant-Bar, wrought-iron in the form of merchantable bars or rods made by shearing muck-bar into short lengths, piling it and rolling or forging it at a welding-heat.			
Bloom 1. A large bar, drawn from an ingot or similar mass, for further manufacture. 2. A rough bar of wrought-iron drawn from a Catalan or bloomary ball for further manufacture.	Bloom.	Luppe. Wolf.	
Billet, a small bar drawn from a pile, bloom or ingot for further manufacture. The committee recommends that the line between blooms and billets be drawn at the size of 5 in. square,[7] as representing common custom.	Billette.	Packet.	
Slab, a flat piece or plate, with its largest surfaces plane, drawn or sheared from an ingot or like mass for further treatment.			

IV. The Boundary Between Steel and Iron.

It would be well to decide on a definite carbon-content to serve as a boundary line between ingot-iron and ingot-steel, between puddled-iron and puddled-steel, and between any other varieties of wrought-iron and weld-steel. Two plans have been considered. One is to draw this line at 0.32 per cent. of carbon or its equivalent in other elements, for the reason that this carbon-content appears to correspond to the critical point, O, in the diagrams of Roberts-Austen and Roozeboom.[8] This has the merit of corresponding to a definite physical boundary.

The other plan is to draw the boundary at 0.20 per cent. of carbon, because this is a convenient place to separate the important classes "soft steel" and "half-hard steel," so that if this point was adopted "ingot-iron" would be synonymous with "soft steel," and "ingot-steel" would be the equivalent of the two classes, "half-hard steel" and "hard steel."

Cambridge, Mass., March 31, 1906.

[7] Pourcel suggests 45 mm. as a dividing line. Brinell recommends 6 in. square.

[8] Mr. Pourcel would classify solely according to the presence or absence of slag, so that "steel" should include all forms of iron freed from slag by fusion and cast in a malleable condition, and "wrought-iron" should include all classes produced in a pasty condition. He does not think that any cross-classification according to the proportion of carbon is expedient.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Proceedings of the Ninety-fourth Meeting, New York, February, 1908.

THIS meeting was held at the home of the Institute in the United Engineering Society Building, 29 West 39th St., New York, N. Y., Feb. 18 to 21, 1908.

The first session, held in the large auditorium Tuesday evening, Feb. 18, was called to order at 8 p.m. by Prof. Henry M. Howe, Past-President of the Institute, who welcomed the members and guests in a few cordial and well-chosen remarks.

The following papers, accompanied by lantern-illustrations, were presented in oral abstract by their authors:

Swedenborg and Humboldt, by R. W. Raymond, New York, N. Y.

Electric Power in Steel Mills, by David B. Rushmore and Karl A. Pauly, Syracuse, N. Y.

At the close of the session, an informal reception in the offices of the Institute was tendered to members and guests.

The second session, held in Assembly Room No. 1 in the same building, Wednesday, Feb. 19, was called to order at 10 a.m. by Prof. Robert H. Richards, Past-President of the Institute. Before proceeding with the papers on iron and steel, which were scheduled for presentation at this session, Mr. F. E. Junge, a representative of the gas-engine and electric motor industry of Berlin, Germany, gave a short oral discussion of the paper by Mr. Rushmore and Mr. Pauly, Electric Power in Steel Mills.

Printed copies of the paper, Uniform Nomenclature of Iron and Steel, were distributed among the members and guests present, and the request was made for a later discussion of this important subject by letter. This paper constitutes the Report of Committee No. 24, of the International Association for Testing Materials, which was presented at the Brussels Congress in 1906.

The following paper was presented in oral abstract by the author:

The Work of the Testing Department of the Watertown Arsenal, in Its Relation to the Metallurgy of Steel, by James E. Howard, Albany, N. Y.*

Piping and Segregation in Steel Ingots, 2d Paper, by Henry M. Howe, New York, N. Y.

An animated discussion of Mr. Howard's paper then followed, part of which was by letter and part in person. In the absence of the authors, the Secretary presented an oral abstract of the contributions from R. W. Mahon, of the New York Central & Hudson River Railroad Co., New York, N. Y.; J. A. Kinkaed, of the American Locomotive Co., Schenectady, N. Y.; Charles L. Huston, of the Lukens Iron & Steel Foundry, Coatesville, Pa.; F. N. Speller, of the National Tube Co., Pittsburg, Pa.; and Charles S. Churchill, of the Norfolk & Western Railway, Norfolk, Va. J. P. Snow, of the Boston & Maine Railroad, Boston, Mass., discussed the paper orally, and, in connection therewith, he exhibited a number of specimens and photographs of rails that had failed.

In the absence of the author, the Secretary presented an oral abstract of a discussion by Dr. P. H. Dudley, New York, N. Y., of Prof. Howe's paper, Piping and Segregation in Steel Ingots, Preliminary Paper,† which was followed by an oral discussion by Prof. Howe, New York, N. Y.; Hiram W. Hixon, Philadelphia, Pa.; R. W. Raymond, New York, N. Y.; Henry D. Hibbard, New York, N. Y.; A. A. Stevenson, Burnham, Pa.; and Prof. William Campbell, New York, N. Y.

The third session, held in the same place, was called to order at 2.30 p.m. by Dr. James Douglas, Past-President of the Institute.

The following paper was presented in oral abstract by its author:

Present Mining Conditions on the Rand, by Thomas H. Leggett, New York, N. Y. Mr. Leggett's paper was followed by a few remarks on the same subject by Alfred James, President of the Institution of Mining and Metallurgy.

The following paper was presented in oral abstract by the Secretary in the absence of the author:

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* Printed copies distributed at the meeting.

† *Bi-Monthly Bulletin*, No. 14, March, 1907, pp. 169 to 274.

The Chinese on the Rand, by T. Lane Carter, Luipards Vlei, Transvaal, South Africa.

The following paper was presented in oral abstract by the author:

The Briquetting-Plant at Bankhead, Alberta, Canada, by Edward W. Parker, Washington, D. C. Mr. Parker's paper was discussed orally by William H. Blauvelt, Syracuse, N. Y.; Dr. James Douglas, New York, N. Y.; and C. G. Atwater, New York, N. Y.

Then followed a continued discussion of Prof. Howe's paper, Piping and Segregation in Steel Ingots, by Prof. Howe and A. A. Stevenson.

The following paper, illustrated by a working-model, was presented in oral abstract by the author:

Compression of Semi-Liquid Steel-Ingots, by N. Lilienberg, Philadelphia, Pa.*

The fourth and concluding session, held in the same place, was called to order at 8 p.m. by Dr. James Douglas, Past-President of the Institute.

The following papers, illustrated by lantern-views, were presented in oral abstract by their authors:

The Physical Features of Peru, in Relation to the Mining Industry, by George I. Adams, Washington, D. C.

The Wilfley Table, II., by Robert H. Richards, Boston, Mass.

The following papers were presented in oral abstract by their authors:

The Work of the Technologic Branch of the U. S. Geological Survey, by Joseph A. Holmes, Washington, D. C.

Recent Coal-Mine Disasters in the United States, by Joseph A. Holmes, Washington, D. C.

The Cause of the Explosion in the Monongah Coal-Mine, at Monongah, W. Va., by Frank Haas, Monongah, W. Va.

A Possible Explanation of the Occurrences of Secondary Mine-Explosions, by W. O. Snelling, Washington, D. C.

Sulphur Di-oxide as an Agent in Fighting Mine-Fires, by W. O. Snelling, Washington, D. C.

* A description of Mr. Lilienberg's apparatus was published in the *Journal of the Franklin Institute*, February, 1908, pp. 121 to 140.

The Relation of Magmatic Waters to Volcanic Action, etc., by Hiram W. Hixon, Philadelphia, Pa.

The following papers were presented in printed form:

The Central Power-Station of the De Beers Consolidated Mines, Ltd., Kimberley, South Africa, by Percy A. Robbins, New York, N. Y.*

The Bogoslovsk Mining Estate, by William H. Shockley, Tonopah, Nev.*

Dip and Pitch, by R. W. Raymond, New York, N. Y.*

Genesis of the Lake Valley Silver-Deposits in New Mexico, by Charles R. Keyes, Des Moines, Iowa.†

Discussion of Mr. Lee's Paper, The Corrosion of Water-Jackets of Copper Blast-Furnaces, by William Kent, Syracuse, N. Y.; James Douglas, New York, N. Y.; Hiram W. Hixon, Victoria Mines, Ont., Can.; and George D. Van Arsdale, New York, N. Y.*

Diamonds in Arkansas, by Dr. George F. Kunz, New York, N. Y., and H. S. Washington, Locust, N. J.*

Blast-Furnace Practice (Supplementary Note), by T. F. Witherbee, Melrose Highlands, Mass.‡

Biographical Notice of Thomas Septimus Austin, by Arthur S. Dwight, New York, N. Y.§

The following papers were presented in manuscript form:

Charcoal and Coke as Blast-Furnace Fuels, by R. H. Sweetser, Sault Ste. Marie, Ont., Canada.

Primary Gold in a Colorado Granite, by John B. Hastings, Denver, Colo.

The Mechanical Preparation of Ores in Sardinia, by Erminio Ferraris, Monteponi, Sardinia, Italy.

Converting Copper-Matte, by Redick R. Moore, Oaxaca, Mexico.

Discussion of Mr. Sweetser's Paper, Chlorination of Gold-Ores, by Charles H. White, Boston, Mass.

Volcanic Waters, by John B. Hastings, Denver, Colo.

Origin of Pegmatite, by John B. Hastings, Denver, Colo.

The following papers were read by title:

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* *Bi-Monthly Bulletin*, No. 20, March, 1908.

† *Bi-Monthly Bulletin*, No. 19, January, 1908, pp. 1 to 31.

‡ *Bi-Monthly Bulletin*, No. 17, September, 1907, pp. 845, 846.

§ *Bi-Monthly Bulletin*, No. 19, January, 1908, pp. 69 to 74.

The Mineral Resources and Industries of Korea, by Hallet P. Robbins, Albany, N. Y.

Kaffir Labor on the Rand, by T. Lane Carter, Luipards Vlei, Transvaal, South Africa.

The Coal-Deposits of Some of the Philippine Islands, by J. B. Dilworth, Philadelphia, Pa.

The Iron-Ore Supply of the Scandinavian Peninsula, by Hjalmar Sjögren, Stockholm, Sweden.

Fly-Wheel Hoists, by David B. Rushmore, Schenectady, N. Y.

Discussion of Mr. R. G. Brown's Paper, The Vein-System of the Standard Mine, Bodie, Cal., by H. W. Turner, Portland, Ore.

The Distribution of the Elements in Igneous Rocks, by Henry S. Washington, Locust, N. J.

Colombia's Future Gold Output, by Henry C. Granger, New York, N. Y.

Notes on the Carbon and Iron Diagram, by Henry M. Howe, New York, N. Y.

Dredging in the Chocon River, Colombia, by Henry G. Granger.

EXCURSIONS AND ENTERTAINMENTS.

Thursday morning, February 20, *at* 9.30 *a.m.* Through the courtesy of Mr. Alfred Noble, Chief Engineer of the East River Division of the Penna., N. Y. & L. I. R. R., a party of about 50 members and guests met at 33d St. and 9th Ave., and viewed the work at the enormous excavation for the great terminal station of the Pennsylvania Railroad. After the inspection was finished, the party formed two divisions, one going underground through the cross-town tunnel, by the courtesy of Mr. D. L. Hough, President of the United Engineering & Contracting Co., and the other proceeding overground in an easier way, by cars, to the compressor-plant at the entrance of the tunnels at 33d St. and East river. The compressor-plant is the largest in the world for river-tunnel work. A brief description of the Manhattan cross-town tunnels, printed in pamphlet form, was distributed to members of the party. This description is reprinted later in this section through the courtesy of the United Engineering & Contracting Co.

Thursday afternoon, February 20. Two parties were formed; one for members only, and the other for members, guests and

their ladies. The first party, through the courtesy of Mr. Charles M. Jacobs, Chief Engineer of the North River Division of the Penna., N. Y. & L. I. R. R., met at 33d St. and 9th Ave., at 2.30 p.m., and proceeded through the Pennsylvania tunnel under the North river to the large shaft at Bergen Hill, N. J. The plant at the surface was inspected, and the return trip to New York followed, part going by hand-car, and part on foot. Later, the station at Christopher St., and the cars of the Hudson & Manhattan Railroad Co., were inspected, and an informal trip was made through the McAdoo tunnel (also called the "Old" Hudson River Tunnel) to the terminal of the D., L. & W. R. R. at Hoboken. This tunnel is the one through which the Institute party walked from New York to New Jersey and return, at the time of the New York meeting in April, 1907.

Mr. Calvin W. Rice, Secretary of the American Society of Mechanical Engineers, kindly provided copies of a pamphlet describing the tunnels of the Hudson Companies, prepared by Mr. S. D. V. Burr, for the visit of that Society in December, 1907. Through the courtesy of the Society, this pamphlet is reprinted later in this section. The two reprints, together with the paper by Mr. H. T. Hildage, entitled Mining Operations in New York City and Vicinity,* present a comprehensive idea of the tunnel-work, from both a popular and a technical point of view.

Thursday afternoon, at 3 *p.m.* A visit was made to the American Museum of Natural History, 77th St. and Columbus Ave., where the party was received by Dr. and Mrs. E. O. Hovey. Various departments were viewed, and all were pleased with the many unique and interesting exhibits. Printed catalogues were available for all specially concerned.

Thursday evening, at 8.45 *p.m.* A formal reception, with music and collation, was given in the Assembly Rooms of the United Engineering Society Building to members and guests. This function was the official social meeting of the Institute, and many took advantage of the opportunity to renew old friendships and to form new ones.

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* *Bi-Monthly Bulletin*, No. 15, May, 1907, pp. 461 to 497, and *Trans.*, xxxviii., 360 to 397 (in press).

Friday morning, February 21, at 10 a.m. A visit of inspection was made to the Terminal Building, Dey and Church Streets. An interesting and instructive tour was made through the lower floors and cellars of the building, finally reaching the west wall of the foundations, through which shields are to be driven to connect with the tunnels under the North river. The party then proceeded to Pier 10 and boarded the steamer *Commodore* for the trip to the refinery of the Standard Oil Co., at Bayonne, N. J. A delightful luncheon was served on the trip down the bay, and the remainder of the afternoon was devoted to the numerous departments of the company, beginning with the receipt of the crude oil by pipe-line, and finishing with the stowing aboard steamer of the refined products, either in boxed cans, in barrels, or pumped direct to tank-steamers. The vast extent of the refinery may be appreciated from the fact that the buildings, tanks, retorts, etc., crowd a space of 300 acres. The company has purchased 400 additional acres on the water front, south of Elizabethport, in order to have room for needed expansion. The daily capacity of this refinery amounts to 40,000 bbl. of crude oil, which at present is piped from Ohio, Indiana, Illinois and Indian Territory, the last-named locality being about 1,900 miles distant. Refined petroleum and naphthas are made here, the by-products being sent to other refining-works of the company (as, for instance, the Eagle Works, in Jersey City, N. J.), for conversion into lubricating and allied oils, paraffine, etc., which are then returned to Bayonne for export shipment. The average daily shipments by steamer amount to 30,000 bbl. of refined petroleum in bulk by tank-steamers for England and the Continent, and 10,000 bbl. in cased cans or barrels for the Orient and other distant places. The return trip up the bay in the bright sunshine was enjoyed by all. The steamer and the luncheon were generously provided by the Standard Oil Co., whose representatives, Messrs. James Smith, A. W. Gilmore, H. Krebs and Clifford McKee, did all that could be done to make the visit memorable for good fellowship and cordial hospitality.

Friday afternoon, at 2 p.m. A party, limited in number, met at the 92d St. ferry, East river, and proceeded to Astoria, L. I., to visit the enormous plant of the Consolidated Gas Co. of New York. The plant is situated some distance from the

ferry, and conveyances for the visitors were thoughtfully provided by the company. The invitation to visit the plant was extended through the kindness of Mr. W. H. Bradley, Chief Engineer, and Mr. Colin C. Simpson, Assistant Secretary, of the company. The following description of the plant has been condensed from the series of illustrated articles published in the *Progressive Age*, vol. xxiii. (1905), during the first part of the construction of the plant:

The magnitude of this plant is apparent from the area of 360 acres covered. The full plan calls for six coal-gas units, each of a daily capacity of 20,000,000 cu. ft., and three water-gas units, each of 40,000,000 cu. ft., making a total of 240,000,000 cu. ft. of gas daily. At present, one unit is being operated, yielding daily 20,000,000 cu. ft. of gas. Every approved device for the economical handling of the raw materials required for the manufacture of gas and the disposition of the gas itself, together with the secondary by-products, has been incorporated in the construction of the first unit, and the most modern appliances for purifying the gas have been adopted. The consumption of coal by the entire plant when completed will amount to 12,000 tons daily, which will yield about half its weight in coke.

The first unit completed contains an equal number of horizontal and of inclined retorts, and from the comparative results of these two types operated under the conditions existing at Astoria, the better type can be ascertained before the entire installation is completed.

The house for the inclined retorts is of concrete construction. It contains 64 benches of 9's arranged in 8 stacks, each 8 benches having an independent flue and chimney, the latter, 4 ft. 6 in. in internal diameter and 130 ft. high, being lined with fire-brick for the first 75 ft. of height.

The house for the horizontal retorts is of steel frame and brick-lined walls, having the charging- and discharging-floors of reinforced concrete covered with special tiling. This house contains 60 benches of "through" retorts, each 21 ft. 9 in. long, arranged in 6 stacks of 10 each and forming two lines of through benches lengthwise of the building. The benches are 8-in. and vertical, with retorts 16 by 26 in. in cross-section. Each set of 5 benches has an independent flue running through the center of the stack. West chargers supply coal to the retorts from either end, and the gas is likewise taken off from either end by independent pipes. The coke, discharged from one end by a mechanical pusher, falls into a West conveyor placed under the charging-floor, and is carried away and quenched.

The building for the boiler-plant is of steel frame with brick-lined walls. It contains four 400-h.p. units of Babcock & Wilcox boilers set in two batteries. The draft is supplied by a stack 8 ft. in diameter and 150 ft. high, built of radial perforated brick.

The exhauster-house, directly in the rear of the boiler-house, contains 5 rotary exhausters having direct-connected horizontal steam-engines. Two of these exhausters can handle the production of one retort-house, and in emergency three could be forced to handle the output from both retort-houses. Each exhauster has a gas-connection at the top, and the trunk-lines are so arranged that the product of each retort-house is kept separate. Air-compressors for supplying power

to the purifier-house cranes, valves, etc., are also contained in the exhauster-house.

The scrubbing- and condensing-house contains tar-extractors, cyanogen scrubbers, naphthaline scrubbers, condensers and ammonia scrubbers. The gas, leaving the exhausters, passes through the apparatus in the order named. There are 6 units of each type, 3 for each retort-house. The purifying department is in two similar houses, each containing 12 cast-iron plate boxes, 40 ft. square and 18 ft. deep, so arranged as to be operated in series of three or six.

The meter-house, situated between the two purifier-houses, contains four 16 ft. station-meters equipped with Hinman drums, and so arranged that either the meter or the gas-holder can be "by-passed" by valves inside the building. Two gas-holders, each of a capacity of 15,000,000 cu. ft. (the largest in the world), are placed near each other; the walls of the gas-holder are of special reinforced concrete construction, limestone instead of sand being used with the cement in order to obtain a greater tensile strength. Each tank is 300 ft. in diameter and 48 ft. 6 in. deep. The telescopic gas-holders resting in these tanks are of steel construction, each having 5 lifts of an aggregate height of 240 ft.; a single girder-frame serves all five sections when filled.

The special features of the installation are: the large coal-storage capacity, 1,000,000 tons; the sewer-system; the duplicate system of arrangement of the plant; and the extended use of mechanical devices to replace hand-labor.

The coal is taken from the storage-yard by conveyors, and delivered into the bins of the retort-houses; thence it is passed by gravity into the inclined retorts, or is mechanically charged into the horizontal retorts. One of the admirable features is the arrangement whereby the apparatus may be so connected that any one unit is thrown in or out of operation as desired, which permits of independent testing and repairs. Another interesting feature is the plant for recovering cyanogen, which is the first to be used on a large scale in the United States.

A part of the final installation is a 20-ft. tunnel, large enough to contain six 60-in. gas-mains, to pass under the East river, Ward's Island and the Harlem river, from Astoria to 111th St., Manhattan. In order to build this tunnel in solid rock throughout, one shaft at each end will have to be sunk 250 ft. deep.

Members and Guests.

The following list is believed to comprise the names of members and guests who registered at the Institute headquarters, or attended the various excursions. Nevertheless, so many came and went at various times during the meeting that this list is doubtless incomplete.

List of Members and Guests Registered at Headquarters, or Attending the Excursions.

Mr. E. O'C. Acker..........South Bethlehem, Pa.
Mr. George I. Adams..........Washington, D. C.
Mr. F. F. Amsden..........Harrisburg, Pa.
Mr. C. G. Atwater..........New York, N. Y.
Mr. A. M. Austin..........New York, N. Y.
Mr. G. D. Barron..........New York, N. Y.

Mrs. G. D. Barron....New York, N. Y.
Mr. John Birkinbine....Philadelphia, Pa.
Mr. W. H. Blauvelt....Syracuse, N. Y.
Mr. J. J. Blow....Brooklyn, N. Y.
Mr. R. F. Böhler....New York, N. Y.
Mr. William Campbell....New York, N. Y.
Mr. Henry C. Carr....Westville, Cal.
Mr. J. Parke Channing....New York, N. Y.
Mr. Christianson....New York, N. Y.
Mr. John A. Church....New York, N. Y.
Mrs. John A. Church....New York, N. Y.
Mr. J. M. Clark....Kanawha Falls, W. Va.
Mr. E. T. Clymer....Philadelphia, Pa.
Mr. G. M. Colvocoresses....New York, N. Y.
Mr. Walter R. Crane....New York, N. Y.
Mr. R. H. Cromwell....Brooklyn, N. Y.
Dr. James Douglas....New York, N. Y.
Dr. H. S. Drinker....South Bethlehem, Pa.
Mr. Howard DuBois....Philadelphia, Pa.
Mr. R. G. Dufourcq....New York, N. Y.
Mr. A. S. Dwight....New York, N. Y.
Mrs. A. S. Dwight....New York, N. Y.
Mr. Edmund W. Dwight....Philadelphia, Pa.
Mr. Theodore Dwight....New York, N. Y.
Mr. Anton Eilers....Brooklyn, N. Y.
Mrs. Anton Eilers....Brooklyn, N. Y.
Miss E. Eilers....Brooklyn, N. Y.
Miss M. Eilers....Brooklyn, N. Y.
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Mr. F. A. Eustis....Boston, Mass.
Mr. W. E. C. Eustis....Boston, Mass.
Mr. Francis S. Foote, Jr....Montclair, N. J.
Mr. O. R. Foster....Brooklyn, N. Y.
Mr. Lewis W. Francis....New York, N. Y.
Mr. W. W. Freeman....New York, N. Y.
Miss Freeman....New York, N. Y.
Mr. George McM. Godley....New York, N. Y.
Mr. Gustave M. Gouyard....New York, N. Y.
Mr. Frank Haas....Fairmont, W. Va.
Mr. Alfred E. Hammer....Branford, Conn.
Mr. V. T. Hammer....Branford, Conn.
Mr. Henry D. Hibbard....New York, N. Y.
Mr. R. T. Hill....New York, N. Y.
Mr. Henry H. Hindshaw....New York, N. Y.
Mrs. Henry H. Hindshaw....New York, N. Y.
Mr. H. W. Hixon....Philadelphia, Pa.
Dr. H. O. Hofman....Boston, Mass.
Mr. L. Holbrook....New York, N. Y.
Mrs. L. Holbrook....New York, N. Y.
Mr. E. C. Holden....New York, N. Y.
Dr. Joseph A. Holmes....Washington, D. C.
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Dr. E. O. Hovey....New York, N. Y.
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Mr. J. E. Howard....New York, N. Y.
Dr. Henry M. Howe....New York, N. Y.
Mrs. Henry M. Howe....New York, N. Y.
Mr. George A. Howells....New York, N. Y.
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Mrs. Charles Humphrey....New Brighton, N. Y.
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Mrs. George S. Humphrey....New York, N. Y.
Mr. L. D. Huntoon....New Haven, Conn.
Mr. J. P. Hutchins....New York, N. Y.
Mr. E. S. Hutchinson....Newtown, Pa.
Mrs. E. S. Hutchinson....Newtown, Pa.
Mr. A. O. Ihlseng....New York, N. Y.
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Mr. Alfred Kimber....New York, N. Y.
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Mrs. George F. Kunz....New York, N. Y.
Miss Kunz....New York, N. Y.
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Mr. Horace V. Winchell..........St. Paul, Minn.

The Tunnels of the Hudson Companies.*

BY S. D. V. BURR, NEW YORK, N. Y.

THE ORIGINAL HUDSON RIVER TUNNEL.

NOT quite forty years ago a man of uncommon character entered New York. He had several hundred thousand dollars earned by railroad building in the West. He was not an engineer, but he had ideas of engineering work which he was destined to prove correct. He introduced new ways of tunneling, but his plans had only one distinguishing feature—they were simply interesting as showing how such work could be done; they added nothing to the science, have never been used since his day, and never will be used again.

Engineers of repute ridiculed his proposition; he was an Ishmael in the profession. But if engineers looked askance at him, he certainly returned their contempt in the heartiest fashion, and had no hesitancy about expressing his views of them individually and collectively. This worked to his disadvantage when he afterward tried to raise the means to go on with the work. He found that the opinion of engineers was respected by financiers, and that money would not flow contrary to their advice.

While his conception of large constructions was distinguishingly original, much more marked was his method of demonstrating the feasibility of his schemes. In the present days of great undertakings it is the custom to make the other man pay for the experiments. But the man from the West had other notions of how the thing ought to be done. Having wonderful confidence in his own ability and in his perception of the task before him, he used up all his own money before seeking outside assistance. By building several hundred feet of tunnel he proved the correctness of his theory, and the tunnel then dug forms a part of the present tube.

The result—he failed to finish the tunnel. He was blind in

* Prepared for the American Society of Mechanical Engineers, and here reprinted through the courtesy of that society.

his latter days and died in poverty, but to the end he believed he had pointed the way and shown how a great work should be done.

There was still another important factor influencing the time of completion of this tunnel. Mr. Haskin was a full generation in advance of the age. Twenty and thirty years ago the citizens of New York were not clamoring for the privilege of traveling daily through a hole in the ground under the Hudson. Residents of London were then being educated in underground transportation problems, but here such methods were considered a little uncanny. But times have changed and tunnels are now in fashion. Even then Mr. Haskin expressed the belief that tunnels, not bridges, would eventually solve the question of transportation in congested sections.

The Original Method.

The method of construction devised by D. C. Haskin was principally noteworthy for its remarkable simplicity. He had seen piers sunk by the pneumatic process, and the idea presented itself that the same plan could be applied to a horizontal tube under water. An examination of the silt forming the bed of the Hudson showed it to be peculiarly well adapted for this purpose. This is a deposit caused by the erosion of the rocks of the upper river. It is neither a fine mud, as that term is generally understood, nor a clay; but under certain conditions it possesses some of the characteristics of both. When dry it is an impalpable powder, and when saturated with water it is as difficult to control as any quicksand. But between these two extremes is a state in which it assumes nearly the consistency of clay. When carrying just the right amount of moisture it will stand up like clay and may then be handled in the same way.

Having found material suited to the purpose, the next step was to devise means for taking advantage of its physical properties. Mr. Haskin knew perfectly well that if he could provide a chamber having an air pressure exactly equal to a water pressure upon the exterior, an exceedingly weak partition would serve as a barrier separating the two. Advancing a little nearer his object, he conceived that a tunnel having an exposed and unprotected heading could be constructed through

the silt of the Hudson, provided he kept the pressure of air in the working chamber as nearly as possible equal to the hydrostatic head without. Upon this principle he advanced, and along this line the tunnel was built.

The Hudson Tunnel Railroad Company was organized with a capital of $10,000,000, with Mr. Haskin as president and manager. The river along its southern part varies but little either in depth or width, being about 60 ft. in the deepest part and about one mile wide throughout. The question of location

FIG. 1.—AIRLOCK IN THE OLD HUDSON RIVER TUNNEL.

became therefore one controlled solely by the approaches. On the New Jersey side it was placed about midway between the Erie and Delaware, Lackawanna and Western terminals, where land was cheap and at that time mostly unoccupied. This location also provided for easy connection with the roads just named and with the Pennsylvania, either by surface or underground lines. The eastern end of the tunnel proper was at the foot of Morton street; from there it was possible to go either north, east or south for a terminal station without encountering property having expensive structures upon it. The many

advantages of this location will be perceived upon consulting the accompanying map.

Beginning Work.

After a year spent in borings along the line of the tunnel, actual work was started in November, 1874, by the sinking of a brick shaft on the western shore back of the bulkhead line. This shaft was circular in section, 30 ft. inside diameter, and was sunk to a depth of 60 ft. below high water. At a point

Fig. 2.—Old Hudson River Tunnel, Looking Toward Heading, Showing Radial Struts Resting on "Pilot."

on the river side 29 ft. below the top, an opening was cut to receive an airlock 15 ft. in length by 6 ft. in diameter. From this lock as a starting-point an inclined chamber was carried down to the 60-ft. level, when the tunnels proper were begun.

The temporary entrance, as it was called, was built in the following manner: At the inner or forward end of the lock a small opening was made in the earth and a flanged iron plate put in position at the top of the opening. Plates were added to the side of this first plate until a ring had been formed a little larger than the lock. Successive rings of plates were in-

serted, each being larger in diameter than the one behind it, the whole forming a funnel-shaped chamber having a straight top and a bottom like steps, due to the increasing size of the rings. The last and largest ring was in line with the tunnels. At that time the intention was to build one large tunnel, 24 ft. high and 26 ft. wide; afterward the plans were altered and two tunnels were begun, which were 18 ft. high in the clear and 16 ft. wide.

When the tunnels had been extended some distance it was decided to replace the temporary entrance with a permanent structure making connection with the shaft. The whole thing proved to be a trap of the worst kind, for a blow-out occurred in 1880, the leak being at the junction of the shaft and entrance. Falling material so wedged the inner door of the lock that it could neither be opened nor closed, and the 20 men in the work at the time were caught and drowned.

As illustrating one phase in the character of Mr. Haskin it may be stated that at the inquest following the accident he said that he, and he alone, was responsible for the design and execution of the work, and the censure, if any, should rest upon him. The engineers were mightily relieved when this statement was made.

The work was reopened by sinking a caisson between the shaft and the ends of the tunnels, and connection made through the side of the shaft.

Tunneling through Silt with an Unprotected Heading.

The most novel feature of the entire undertaking was the method of advancing the heading. Excavation was started at the crown and carried down the sides and across the invert. As soon as a space of sufficient size had been opened a flanged plate was put in and bolted to the ring of plates already in place. To facilitate this work the heading was cut in steps, or terraced, and as the plates followed the heading, the iron work resembled a mammoth buggy-top. When four complete rings, making a chamber 10 ft. long, had been placed in position, the section was cleaned out and the masonry laid of hard brick in hydraulic cement. At first the brick work was 24 in. thick, but this was increased to 30 in. when the tunnel approached the deepest part.

The plates could be easily handled by two men, as they were made of ¼-in. boiler iron and were all 2½ ft. wide, but some were 3 and others 6 ft. in length. Edging the plate was a 3-in. angle iron, having holes every 6 in. The plates were supported by timbers resting upon sleepers placed in the silt until the masonry had been built. The men worked in three shifts of 8 hours each, and 5 ft. of finished tunnel a day was considered very good progress.

The plates were only used as a makeshift to hold the silt until the masonry could be laid. With the masonry once in place their existence was a matter of no concern whatever.

Air and Water Balance.

The air pressure varied somewhat and increased as the tunnel approached the deepest part of the river, the maximum being about 38 lb. to the sq. in. The intention was to balance

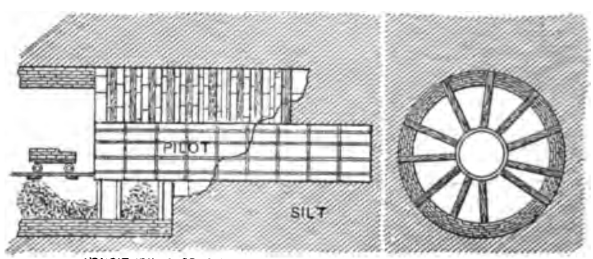

Fig. 3.—Sections of Old Tunnel, Showing the Pilot.

the hydrostatic head at all times, but there was one quite serious stumbling block. The pressure within the heading was the same in all parts, and the air supported the top and bottom with equal force. But with the water pressure it was an entirely different proposition. The excavated heading was about 23 ft. in height, and there was a difference of about 11 lb. in the pressure between the crown and invert. If the air pressure equaled the water pressure at the crown a perfect balance would be maintained at that point, but the water pressure at the invert, being 11 lb. in excess of the air pressure, would force the silt in. An air pressure at the invert balancing the water pressure would permit the air to escape through the crown. It was necessary to strike a medium between the two, and this was found to be a little above the axis of the tunnel. At this point the two pressures were equal.

The men stood upon the steps formed in the face of the heading and shoveled back the silt, which was loaded into cars and carried out. At first it was mixed with water in a large tub and then blown up to the surface through a pipe by means of the air pressure. Afterward it was taken in cars to the foot of the shaft and then raised to the surface by an elevator.

When about 400 ft. of the north tunnel had been completed a bulkhead was built across the tunnel and an airlock put in. When the tunnel had been carried another 1,200 ft. another lock was placed; this divided the work into sections. The principal object in this was to reduce the size of the chamber, which had to be kept filled with air at high pressure, and in that way reduce the operating expense.

Watching for Leaks.

It is very evident that great and constant care had to be exercised in watching for leaks in the silt through which the air was escaping. A small opening would soon become a large one unless plugged. When the hole permitted the air to escape in any quantity its presence was made apparent by the hissing noise caused by the out-rushing air. But small leaks could not be detected in this way, and so men were kept all the time passing candles over the face of the exposed silt at and near the crown. If the flame was drawn in, it indicated the presence of a passage through which the air was escaping. Rubbing the hand over the surface was sufficient to stop small leaks; large ones were filled with a ball of silt. Leaks too large to control in this way resulted in a blow-out, and the flooding of the work. While this occurred several times, the men always had time to reach the locks in advance of the water. The water entered intermittently, like the action of pouring water from an inverted bottle. The blow-outs were generally occasioned by inattention on the part of those appointed to watch, or from the opening of a pocket of sand in the heading. Although the plans had been pronounced dangerous in the extreme, no man lost his life by reason of a blow-out at the heading.

When the crown became so dry that the silt would flake off it indicated too much air pressure; when it became so wet that small streams would form and run down the sides a lack of air

pressure was shown. The pressure was then increased or diminished, as the case might be.

To those not accustomed to the work, the view of that exposed heading was not a cheerful and inspiring sight. The thought was bound to occur that that wall of mud was all that separated the visitor from the waters of the Hudson. Reason as he would, the idea could not be shunned that the partition was of an unstable character; discussing the question of balancing pressures might be an interesting pastime when in the open air, but it was certainly not enchanting when facing a mud barrier 70 or 80 ft. beneath the surface of a river. Nevertheless, the mud partition served its purpose until replaced by the shield.

INTRODUCTION OF THE "PILOT."

It was early found to be impossible to maintain the grade of the tunnel, and the first 400 or 500 ft. of the north tunnel assumed its own grade. This was caused by the settling of the plates of a section before the masonry could be built. It was thought that the trouble could be overcome by erecting the plates a little higher than they should be and depending upon them to settle to the correct grade; this was tried. In some cases it worked to perfection, but in others there was no settlement whatever. The consistency of the silt seemed to vary with every foot passed through, and therefore it was impossible to foretell whether it would settle or not. So serious did this become that it became a question of finding a remedy or abandoning the work.

John F. Anderson, superintendent of the tunnel at that time, proposed what was called a "pilot." He reasoned that if he could provide a central support having sufficient rigidity he could hold the plates with radial braces. After the pilot had been introduced the trouble about grade disappeared.

The pilot was a tube from 50 to 60 ft. long, 6 ft. in diameter, the forward end of which projected some distance into the silt in advance of the heading, and the rear end of which was held centrally in the completed portion of the tunnel. It was made of interchangeable flanged plates which were removed from the rear and placed at the forward end as the work advanced. By this means a stiff center was obtained from which radial timbers held the plates.

One objection to the pilot was the great inconvenience caused by the presence in the heading of such a grove of braces. Some idea of the condition can be obtained from the photograph of the heading, which was taken after the pilot had been used in the building of several hundred feet of tunnel.

Financial Troubles.

During the '80's money troubles caused the stopping of the work for most of the time. People had not yet been converted

Fig. 4.—View Looking from the Heading, Showing Bracing, Centering and Top of Pilot.

to the idea of traveling under water, and funds for a scheme of this kind were hard to get. At that time the north tunnel had been finished about 2,000 ft. from the shaft and the south tunnel about 600 ft. The north tunnel from the New York side had been pushed about 200 ft., the material passed through being mainly sand.

In 1888 the firm of S. Pearson & Son, of England, undertook the contract, having Sir John Fowler and Sir Benjamin Baker, who had just completed the great cantilever Forth Bridge, as consulting engineers. The plans were changed and

the shield method substituted. The masonry lining was done away with and heavy cast-iron plates used instead. This company afterward received the contract for the Pennsylvania tunnels under the East River. After the north tunnel had been pushed about 3,000 ft. from the shaft lack of money again hindered the work, and it was not until 1902 that the final and successful attempt was made to finish the work. At that time the New York and New Jersey Railroad Company acquired the franchise and property of the original company.

The Hudson Companies.

The tunnels are now being finished—they will be opened in a very few weeks—by the Hudson Companies, of which Walter G. Oakman is the president, Charles M. Jacobs, chief engineer, and J. V. Davies, deputy chief engineer. When completed they will be operated by the Hudson and Manhattan Railroad Company, of which William G. McAdoo is president.

When the new interests took charge the north tunnel had been built for a distance of about 3,800 ft. from the New Jersey end. The shield employed by the English company was used, but it was found necessary to change it somewhat, since it was approaching a spur of rock which would project about halfway through the tunnel. Blasting would be necessary and provision had to be made for the men to work outside of the face of the shield in order to drill the rock. A heavy apron, extending 6 ft. in front of the shield and clear across it at the center line, was added. The apron was thoroughly well braced, and under its protection drilling and blasting were carried on without danger to the men and without injuring the shield.

This is the first time in the history of subaqueous tunnel work that rock has been drilled and blasted ahead of a shield with not more than 14 ft. of thin silt overlying the rock and above that 65 ft. of water, the air pressure being at least 38 lb. per sq. inch. At times, due to "blows" and the consequent loss of cover, the river bed was blanketed with clay over and ahead of the shield. Progress in this section was necessarily slow, requiring a period of 11 months to pass through the rock reef. The eastern end of this reef rose abruptly to a pinnacle 17 ft. above the cutting edge of the shield, resulting in a serious blow at this point. The bed of the river was washed in, and

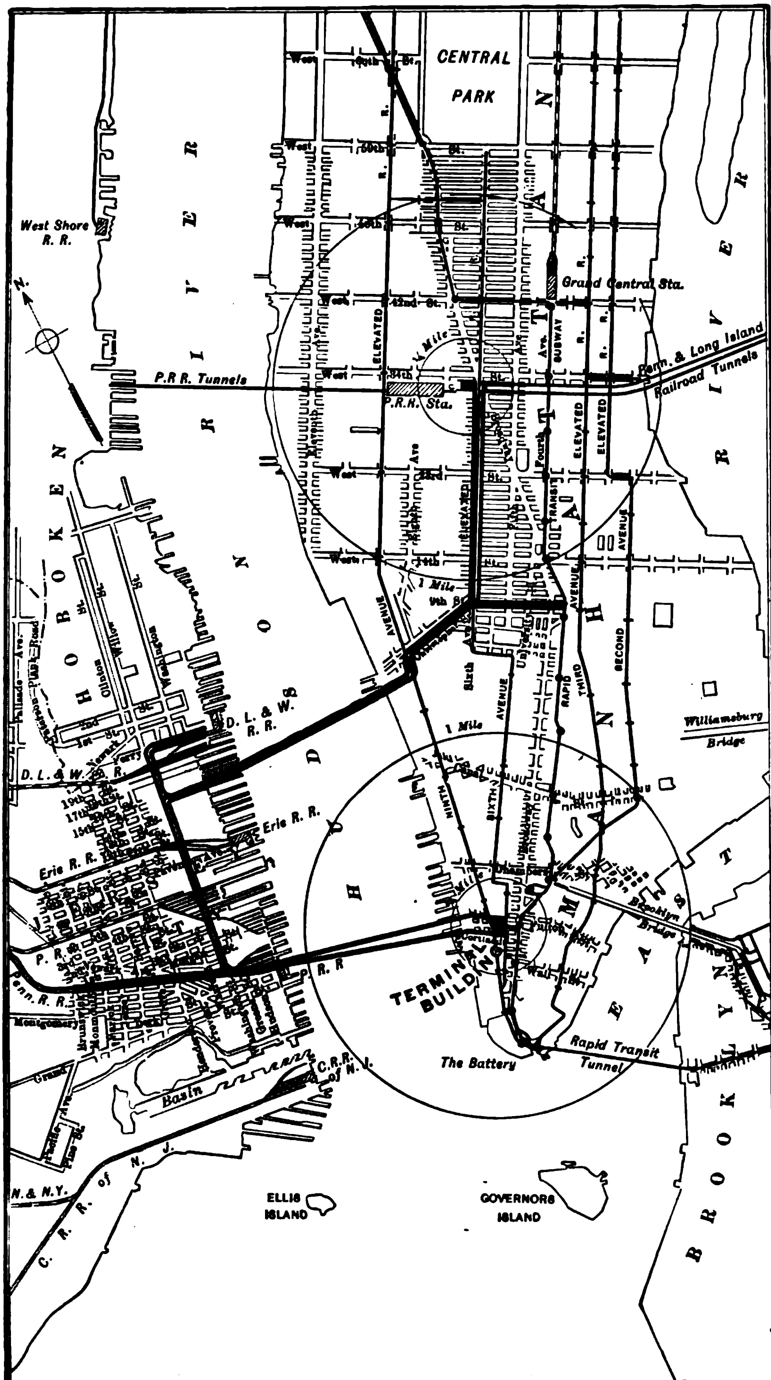

FIG. 5.—THE HUDSON TUNNEL SYSTEM.

the clay which had been deposited from scows followed down into and through the pockets of the shield, becoming uncontrollable.

Overlying the rock was a mixture of silt and sand which offered little resistance to the passage of the air. When the air pressure was reduced in order to overcome this, the mixture would flow down and effectually stop all operations. The apron acted to keep out much of the flow, but not sufficient to permit uninterrupted work. The obstacle was obviated in the following novel manner: The exposed clay was heated with blow torches, which vitrified it to such a degree as to prevent its further flow into the excavation, thus allowing the rock to be reached and drilled and blasted in the usual manner. As soon as this high pinnacle had been passed the rock rapidly disappeared and the shield passed in the sandbeds.

Building the South Tunnel.

Changes of considerable importance were made in the design of the south tunnel. The size was reduced to a diameter of 15 ft. 3 in. in the clear. The plates lining the tube were $6\frac{1}{2}$ ft. long, 2 ft. wide, $1\frac{7}{16}$ in. thick, 8 in. through the flanges, which were $2\frac{1}{4}$ in. thick through the section at the bolt holes. As usual in all work of this kind, the edges of the plates were accurately faced, the long ones being in a plane at right angles with the axis of the tunnel and the short ones on a radius, so that they fitted together perfectly. The plates insured the true circular section of the tunnel, while with the shield it was possible to follow the exact grade and alignment. The plates were raised and held in position until they could be bolted to those already in place by an hydraulic erector carried by the shield.

Tunneling Without Excavating.

The shield, which is shown erected in the shop, consisted of a circular shell a little larger than the outside diameter of the finished tunnel. In the diaphragm were formed openings through which to pass the excavated material. The shield was forced forward by means of 16 hydraulic rams arranged symmetrically near the shell. The total pressure exerted on the shield by the rams was 2,500 tons, equal to about 10 tons to the square foot of the exposed face.

We now come to one of the most beautiful and successful ideas ever introduced in tunneling through soft material. In extending this tunnel, and also the Pennsylvania and Cortlandt street tunnels by the same engineers, no material at all was excavated. While silt is tenacious to a certain degree, it can be forced aside by continued and powerful pressure. Taking

FIG. 6.—SHIELD ERECTED IN SHOP.

advantage of this property the shield was simply pushed through the silt, which moves to one side to permit its passage. It is precisely similar to forcing a stake in the ground; the earth gives way as the stake enters.

Two results followed the adoption of this method. The cost of construction was far less than ever before reached, and the time of building was much less than ever before obtained in

work of like character. Five ft. in 24 hr. was a large output in the original tunnel; with the new method a record of 72 ft. has been made in 24 hr. on the Cortlandt street tunnel. This means that during that time this length of tunnel has been finished ready for the track, and without passing a yard of silt through the working.

Tunneling the New York Approach.

A shield was erected in the caisson at the eastern end of the tunnel, which was used in building the line which extended, as shown upon the map, to Thirty-third street and Broadway. One of the engravings shows the tunnel at the curve at Morton and Greenwich streets. Here the plates were made with a taper so as to obtain an accurate fit. This view also shows the side benches, one of which will be used for carrying the telegraph, telephone and lighting cables and signals, while the other will be reserved for motive power cables, and the top surface will serve as a walk for passengers in case of accident.

Since the charter of the company made no provision for connections in the city, application was made to the Rapid Transit Commission, now the Public Service Commission, for permission to extend the line to Thirty-third street. This was granted with the following conditions: Beginning when the extensions shall have been finished, and ending 25 years from the completion of the work, the company is to pay the city 50 cents per linear foot of single track and of station platform for the first 10 years, and $1 per annum per linear foot during the next 15 years, and an additional sum of 3 per cent. of the gross receipts for the first 10 years and 5 per cent. afterward. These gross receipts are estimated, by the agreement, at $300,000 a year for the first 10 years; after that they are to be determined by the actual traffic returns. At the end of 25 years the rental is to be readjusted.

The New Jersey Approach.

The map very clearly shows the connections made with the several railroads on the New Jersey shore. The south tunnel of the old work was lowered so as to pass under the north tunnel at the shaft, thus avoiding grade crossing. The Hoboken terminal makes connections with the Delaware, Lacka-

FIG. 7.—CURVED TUNNEL AT MORTON AND GREENWICH STREETS, NEW YORK.

wanna and Western; connection is also made with the Erie ferry, and at the Pennsylvania station connection is made with the Cortlandt street tunnels, which are nearing completion.

Reinforced Steel-Concrete Caissons.

Three caissons were sunk at the switch points of the curves just west of the shaft. These caissons were the first of the kind ever built. When they were required steel could not be obtained within any reasonable time and wood was not desirable. Therefore reinforced concrete was adopted. This structure was found to be cheaper to build and to serve the purpose much better than either steel or wood. Two of the caissons measured 105 by 46 by 23 ft. and at the shoe were 47 ft. 5 in. high. These caissons were in each case built on the surface and sunk complete under air pressure to an elevation 85 ft. below tide. They weighed about 10,000 tons each, and are double-decked so as to allow the westbound tunnel to be superimposed on the eastbound, the wide end of the caisson allowing for switches to permit the trains to pass to the north or the south on each deck.

Shields from the river entered the caisson at the narrow end and passed through the north side, while new shields were erected for the south side at the wide end. One of the half-tones shows the end of one of the caissons with the right-hand tunnel completed for some distance, while the shield is just entering the other tunnel.

Two station views are shown. Difficulty was experienced in obtaining a foundation for the Hoboken terminal and it was necessary to introduce a system of inverts. Turning the picture upside down will convey a crude conception of the work underground. The other station was formed by cutting away the adjacent sides of the tunnels, building a platform and throwing an arch between the two.

In the foregoing no attempt has been made to mention in detail all the operations connected with the building of these tunnels; the aim has been to point out a few of the most interesting features and omit all matter of a purely technical character.

Tunnels Built, Building and to be Built in New York.

For the student in tunnel engineering New York city is a Mecca. Here may be found, built or building, about every de-

scription of tunnel ever conceived. At the present time there are six tubes nearing completion under the Hudson—the Pennsylvania, old Hudson and the Cortlandt street tunnels. Nearly

Fig. 8.—Tunnels Started from the Steel-Concrete Caisson.

finished under the East River are the tunnels from the Battery to Brooklyn and forming the Brooklyn extensions of the rapid transit system. The same may be said of the so-called Belmont tunnels from Forty-second street to Brooklyn, and of the Penn-

sylvania tunnels from Thirty-fourth street to Long Island City. In addition, the Public Service Commission have under consideration plans—left by the old Rapid Transit Commission—for extensions to the subway system at least four times the extent of the present subway. These plans call for 18 tracks under the East River through either single or double track tubes. The routes connected with these tunnels cover Manhattan, the Bronx and Brooklyn. They contemplate five north and south routes in New York and four cross-lines below Fifty-ninth street. In Brooklyn, in connection with the present rapid transit systems,

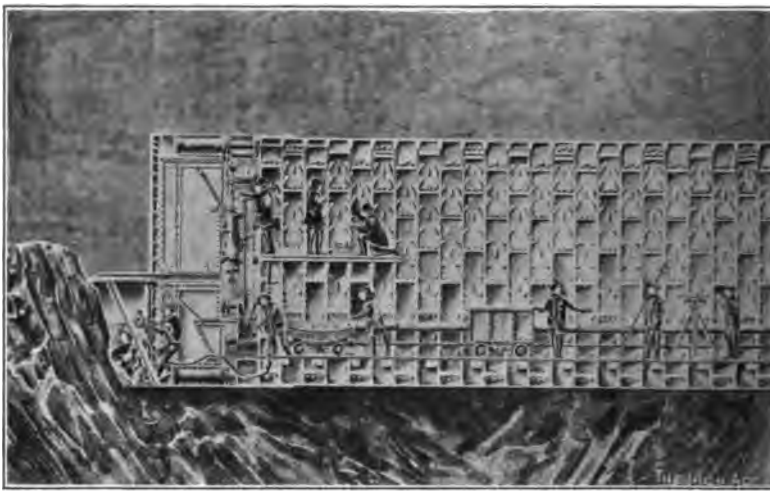

FIG. 9.—VITRIFYING THE CLAY AND SILT IN ADVANCE OF THE SHIELD.

the entire city is to be covered with a network of roads. These lines, together with the Brooklyn, Manhattan, Williamsburg and Blackwell's Island bridges, not to mention the many bridges crossing the Harlem, would seem to provide ample means of transportation between Manhattan and the outlying country, to the north, west and south.

NEW HOBOKEN TERMINAL OF THE DELAWARE, LACKAWANNA AND WESTERN RAILROAD.

Description.

In August, 1905, the Hoboken terminal and ferry-houses of the Delaware, Lackawanna and Western Railroad were burned down. In their place has been constructed one of the most

original train-sheds in the country. It was designed by Lincoln Bush, chief engineer of the road, and is constructed of steel, glass and concrete. It covers 14 tracks and is 607 ft. in length.

In general it consists of a number of arched longitudinal sections having spans of 43 ft., sufficient for two tracks and two platforms. The roof is supported by rows of columns placed in line in the center of the platforms, and the center of the span is 16½ ft. above the top of the rail. Purlins carried by the roof girders support the reinforced concrete roof slabs and the glass skylights.

FIG. 10.—STATION PLATFORM FORMED BY UNITING THE TWO TUNNELS.

Directly over the locomotive smoke stacks and extending the entire length of the shed is an opening through the roof 2 ft. 6 in. wide. As these openings come within 6 or 8 in. of the tops of the stacks, practically all of the smoke and gases pass through the opening into the outer air. The result is that the air in the shed is remarkably free from impurities. The metal roof members directly over the stacks are incased in concrete to protect them from the gases. On the upper edge at each side of the opening is placed a concrete slab 2 ft. high, which further insures the passage of the gases.

Each section is provided with three continuous skylights each 6 ft. wide. The center one will admit light to the inside windows of the cars, while the others will furnish ample light to the outside windows. In each valley of the roof is placed a copper gutter, which is connected with a spout in each of the hollow cast-iron columns.

On the first floor of the main building are the waiting-room

FIG. 11.—TUNNELS UNDER PENNSYLVANIA RAILROAD STATION.

and the ferry entrances. The former is 90 by 100 ft. in the plan and 55 ft. high. The room is finished in limestone and plaster, with high windows on all sides. Ample illumination has been provided for night, in the shape of 1,000 incandescent lights distributed over the space, four immense chandeliers of bronze, weighing over a ton, in each corner, and clusters of lights over the seats. Bronze stairways lead from the waiting-room down to the ferry concourse. From this room open the women's

rooms, baggage and express windows, smoking-room, information bureau and lunch-room. On the second floor, which is reached by an inclined plane and elevators, is the restaurant.

Fig. 12.—Station at the Hoboken Terminal.

Also on this floor are an emergency hospital, barber shop, bathrooms and offices.

Six ferry-slips are provided, each accommodating a large double-deck boat serving Twenty-third street, Christopher and Barclay streets, New York. To reach the boats passen-

gers have a choice of three ways, inclined plane, stairway or elevators.

The whole building is covered with copper, and the plans call for a tower 250 ft. high, which will be illuminated throughout at night.

In addition, there is an immigrant station accommodating 800, having a ferry-slip and house of its own. This building has special tracks and a special ferryboat.

The Manhattan Cross-town Tunnels of the Pennsylvania Railroad.*

The following brief description of the main features of the engineering work was prepared for the use of members of the American Society of Civil Engineers and members of the American Institute of Mining Engineers on the occasion of their visits to the tunnels at the time of their respective annual meetings in New York, January and February, 1908.

Description.

Those portions of the Pennsylvania Extension into Manhattan and Long Island, lying east of the Terminal Station and west of the East River, have been designated as the "Manhattan Cross-town Tunnels." They traverse a section of the city second in importance only to the financial district, and one that includes the larger hotels, retail shops and theaters and the residences of many of the best known citizens.

Section "D," consisting of twin tunnels for west-bound express and local passenger traffic, lies under Thirty-third Street from a point 400 ft. west of the west line of Sixth Avenue, eastward to the river shaft, situated in the block between Thirty-third and Thirty-fourth Streets east of First Avenue.

Beginning at the east end, the tunnels are in separate excavations, leading westward from the subaqueous tubes, on a curve of large radius, gradually closing together until it is found more appropriate to drive them in a single excavation. At a point just west of Second Avenue they reach the tangent, and from there westward lie directly under Thirty-third Street. At a point about 180 ft. west of the west line of Sixth Avenue, the center concrete-wall between the twin tunnels is omitted, and the excavation somewhat widened to make room for a third storage-track, and the tunnel continues to the station portal in three-track section.

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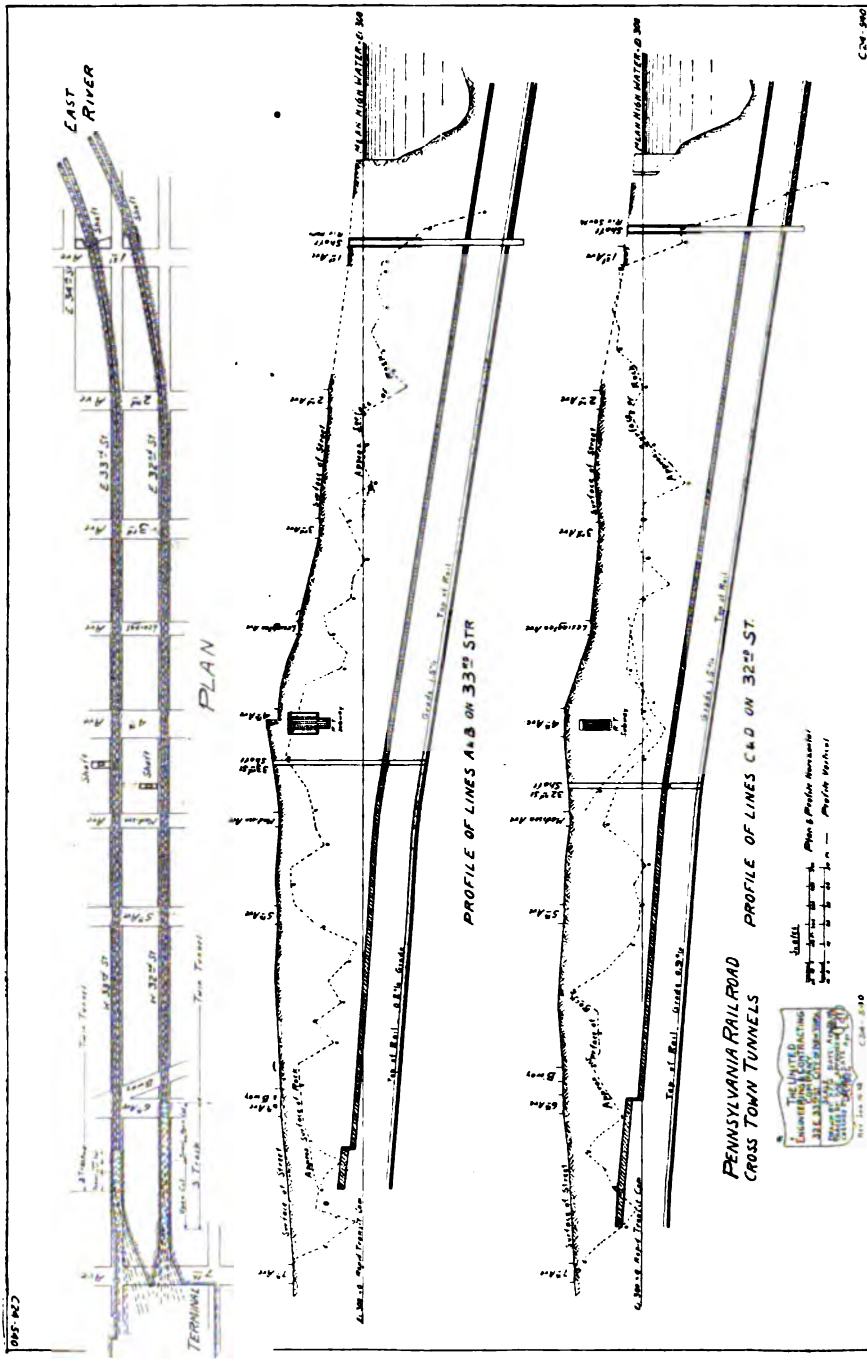
* Here reprinted through the courtesy of The United Engineering and Contracting Co. The half-tone blocks used for the illustration of this paper have been kindly supplied by the Chasmar-Winchell Press of New York, Pittsburgh and Cleveland.


East River
Plan
Terminal
Profile of Lines A & B on 33rd Str
Profile of Lines C & D on 32nd St.
Pennsylvania Railroad
Cross Town Tunnels

Section "F," consisting of twin tunnels for east-bound express and local passenger traffic, lies under Thirty-second Street from a point about 800 ft. west of the west line of Sixth

FIG. 2.—TYPICAL SHAFT HEAD HOUSE, 45 AND 47 EAST 33D STREET.

Avenue, eastward to the river-shaft, situated in the block between Thirty-second and Thirty-third Streets east of First Avenue. This section is a counterpart of section "D," with

the exception that the three-track section has its beginning 25 ft. west of the east line of Sixth Avenue, and continues thence westward to the station.

The contract for sections "D" and "F" was signed with The United Engineering and Contracting Co. on May 29, 1905, and ground was broken for the intermediate shaft sunk in the property known as No. 31 East Thirty-second Street on June 6, 1905.

Ground was broken for the intermediate shaft sunk in the property known as Nos. 45 and 47 East Thirty-third Street on July 7, 1905.

From these two intermediate shafts, headings were driven both eastward and westward. In January, 1906, the west

FIG. 3.—ONE OF FIVE ELECTRIC-DRIVEN COMPRESSORS.

halves of the river-shafts were turned over to the contractor, and headings were started westward. The excavation was completed between the intermediate shaft and the river-shaft under Thirty-third Street in January, 1907. The excavation was completed from intermediate shaft to river-shaft under Thirty-second Street, March, 1907.

In March, 1907, shafts were sunk in both streets about 200 ft. west of Sixth Avenue, and headings were driven eastward and westward. The excavation under Thirty-third Street is now completed. The excavation under Thirty-second Street will be completed in April, 1908.

Work was commenced on concrete in April, 1907, and the concrete completed from the East River to the intermediate

shafts in Thirty-second and Thirty-third Streets before the close of navigation in December, 1907.

FIG. 4.—TELPHER BETWEEN THIRTY-FOURTH AND THIRTY-SECOND STREETS, EAST OF FIRST AVENUE.

Some concrete-work is now under way at the west end and adjoining Fifth Avenue, with the expectation that the concrete

FIG. 5.—STEAM-SHOVEL OPERATED BY COMPRESSED AIR.

will be completed in Thirty-third Street in July and in Thirty-second Street in October, 1908.

So much of both of the structures lying east of Sixth Avenue has been built entirely by tunneling through rock.

The work in Thirty-third Street from a point 180 ft. west of the west line of Sixth Avenue has been built by open cut, as has also been all but 120 ft. of the work west of the line 25 ft. west of the east line of Sixth Avenue under Thirty-second Street.

Many difficult problems have had to be solved in the conduct of the work, both in the drilling of the rock and handling

Fig. 6.—Meeting of the Headings.

of the explosives, in order that no damage might be done to the overlying and adjoining structures, and in getting through the soft materials, where encountered, without causing settlement. In this connection credit is due Mr. Paul Brown for systems of excavating and timbering originated by him. At the present time, with Thirty-third Street completed and Thirty-second Street well under way, the difficulties are largely overcome.

The general features of the structure can be seen from the

illustrations. One of the greatest difficulties with which the contractor has had to contend has been the details of the concrete to make the tunnels appropriate for electrical operation.

The illustrations do not show the refuge niches, ladders,

FIG. 7.—TYPICAL CONCRETE PLANT AT INTERMEDIATE SHAFTS.

cross-passages and other safety-arrangements, or the manholes, splicing and circuit-breaking chambers that are spaced with great frequency throughout the length of the work, and in these illustrations the ducts that are laid in the bench walls, both sides, have largely been covered by plank protection.

Fig. 8.—Typical Train.

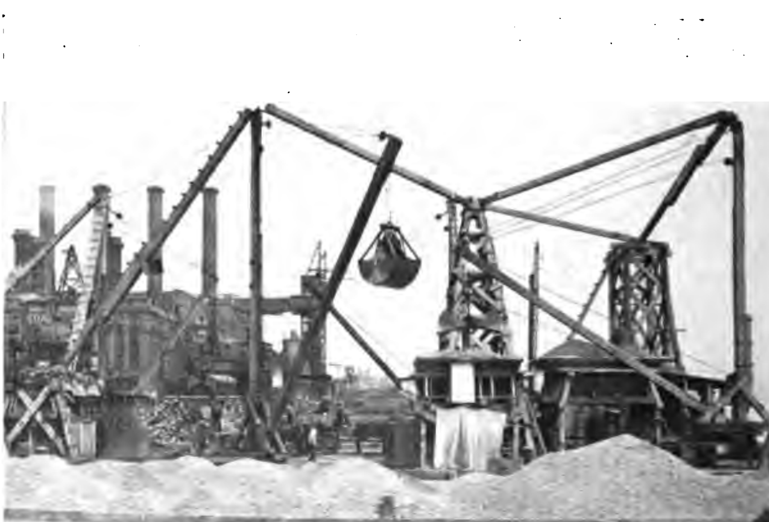


Fig. 9.—Disposal and Receiving Dock, Foot of Thirty-fifth Street, East River.

The chief quantities of materials handled on the work are:

	Cubic Yards.
Excavation, rock,	390,000
Excavation, earth,	40,000
Concrete,	150,000
Brick,	13,000

PLANT.

An unusual feature of this contract is the fact that the power used is wholly electricity. There is not a pound of coal burned on the job, other than that used by the black-smiths and drill-sharpeners. The drills are driven by compressed air, generated by electrically-driven compressors. All the hoists and motive power are driven by electricity, or by air in turn produced by electricity. The driving-current is secured from the street mains of the New York Edison Co. The compressors were built by the Laidlaw-Dunn-Gordon Co.; the telphers by the Dodge Coal Storage Co.; the hoisting-engines by the Lambert Co. The drills and other equipment were furnished by the Ingersoll-Rand Co.; and every bit of the electrical machinery has been furnished by the General Electric Co.; and the cars by the Ernst Wiener Co.

DISPOSAL.

A very material factor in the successful conduct of the work has been a bucket of special design, in the development of which Mr. George Perrine co-operated with Mr. Hough. This bucket is made in two interchangeable halves, supported when being lifted, loaded, at the center, and is kept closed by gravity on the principle of an ice tongs. When it is desired to dump, hooks are attached to the sides and the center supports are lowered away. These buckets, shown in many of the illustrations, are filled in the tunnel, usually by a steam-shovel driven by compressed air, are transported on platform-cars to the shafts, hoisted thence and put upon platform-trucks, on which they are drawn to the dock and dumped by a special mechanism attached to the hoisting-engines. The teaming is all done by the Thomas Crimmins Contracting Co. The steam-shovels were made by the Merion Steam Shovel Co.

(Railroad Gazette.)

Fig. 10.—Typical Excavations, Twin Tunnels.

MATERIALS.

The materials have been furnished by the following concerns:

Powder—E. I. Du Pont de Nemours Powder Co.

Oils—Borne & Scrymser.

Broken Stone—Clinton Point Stone Co.

Sand—Goodwin Brothers.

Duct—Great Eastern Clay Co.

Structural Steel—American Bridge Co. and Milliken Brothers.

Cement—By the Railroad Company itself.

Brick—Through Fredenburg & Lounsbury by the Bessemer Limestone Co., of Youngstown, Ohio.

Timber—Frank J. Parks.

Waterproofing Subcontractor—Sicilian Asphalt Paving Co.

Metal Concrete Forms—The Logan Iron Works.

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FIG. 11.—TYPICAL CROSS-SECTION, TWIN TUNNELS.

(*Railroad Gazette.*)

FIG. 12.—TYPICAL EXCAVATION, THREE-TRACK SECTION.

FIG. 13.—TYPICAL CROSS-SECTION, THREE-TRACK TUNNEL, BRICK ARCH.

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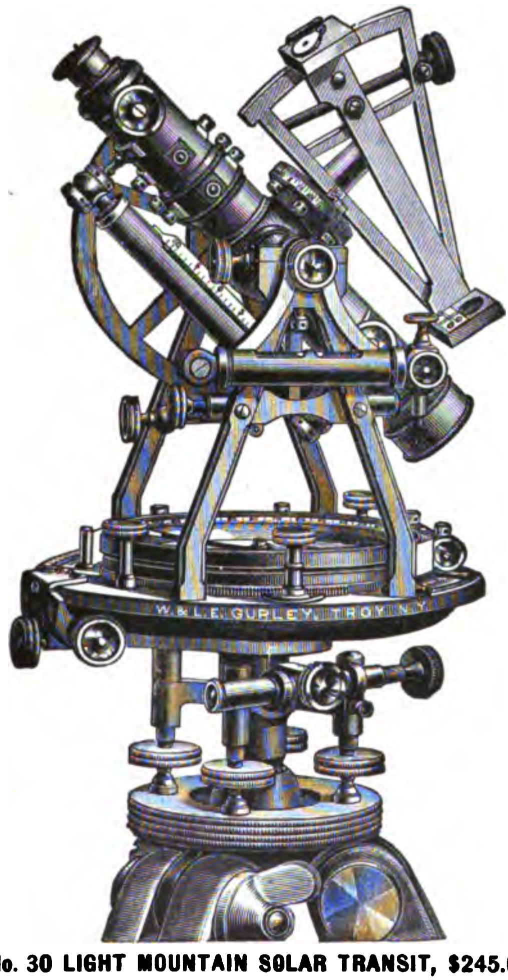

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TABLE OF CONTENTS.

SECTION I. INSTITUTE ANNOUNCEMENTS.

SECTION II. TECHNICAL PAPERS.

ERRATA.

Corrections to *Bi-Monthly Bulletin*, No. 20, March, 1908:

Page lix, lines 8 and 9. For "Oct. 12" read "Dec. 20."

Page 248. After line 34, add: "Dr. Persifor Frazer, Philadelphia, Pa."

BI-MONTHLY BULLETIN.

SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York City (Telephone number 4600 Bryant).

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This volume, an octavo of 700 pages, is now ready for delivery. By its aid, any subject treated or alluded to in the *Transactions* can be instantly tracked. The names of persons, mines, works, towns, etc., have been included; and abundant cross-references and classified sub-headings have been added to facilitate rapid consultation. Thus, the student remembering the name but not the locality, or the locality but not the name, or neither the name nor the precise locality of a gold-mine, can find it under "Gold-mines," or under either of the other heads. For a more extended statement of the nature and use of this Index, which is intended specially for the benefit of those who do not possess complete sets of the *Transactions*, and who consult the Library by correspondence, see the *Bi-Monthly Bulletin* for September, 1907. The price of the Index bound in cloth is $5, delivery charges prepaid. Half-morocco binding costs $1 extra.

Buy at once a copy of this Index, and also as many back-volumes of the Transactions as you can afford. Every such purchase from the stock on hand is so much added to the income of the Institute. As far as possible, the money thus received will be devoted to maintaining and perfecting the Library, and making it useful to members in all parts of the world.

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ANNOUNCEMENT.

THE BIRMINGHAM MEETING.

The XCIVth Meeting of the Institute for the reading and discussion of professional papers will be held at Birmingham, Ala., beginning about October 1. After the Birmingham sessions and excursions, it is proposed to return by special train via Chattanooga, Ducktown, etc., to Washington, D. C., where additional sessions will be held. Further particulars will be given in a special circular, to be issued at an early day.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
AMERICAN INSTITUTE OF MINING ENGINEERS.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays.

RULES.

For the protection and convenience of members, the following rules have been adopted:

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room.

This card, as well as any card of introduction given to a non-member, must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

Strangers who desire to enjoy the privilege of entering the alcoves are requested to present either letters of introduction from members, or cards, such as will be furnished upon application by the Secretary of each Society. The first two alcoves are free to all; and admission to the inside alcoves is given upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

SPECIAL INQUIRY.

Do you Possess, or Can you Obtain, and Will you Give, or Sell, to the Institute Library

Early Volumes of the following Proceedings and Journals?

American Chemical Society. *Journal.*
Wanting: Vol. 3, Nos. 8–12 (1881); Vol. 4 (1882); Vol. 5 (1883); Vol. 6, Nos. 1–3 (1884).

American Foundrymen's Association. *Journal.*
Wanting: Vols. 1–4; Vol. 5, Nos. 26, 28–30; Vol. 6, Nos. 31–35; Vol. 7, No. 41; Vol. 8, No. 48.

Australian Mining Standard, Sydney (Australia).
Wanting: Vols. 1–10 (1888–'94); Vol. 11 (1895), No. 370, and all Nos. before No. 356 and all after No. 372; Vol. 13, Nos. 429, 440, 441, 443, 460, 462, 468, 472, 476; Vol. 13, 479, 490, 492, 497; Vol. 14, Nos. 512, 515, 518; Vol. 15, Nos. 536, 545, 550, 552–554, 557, 559, 562, 566, 567, 581; Vol. 17, Jan.–June; Vol. 18, p. 1–425 (July–Oct. 11); Vol. 19, Nos. 637–639, 647; Vol. 20, Nos. 661, 662, 680, and p. 543 and index; Vols. 21–27.

Chemical Society of London. *Journal.*
Wanting: Vols. 1–26.

Deutsche Chemische Gesellschaft. *Berichte.*
Wanting: Vols. 1–6 (1868–'74).

Foundry.
Wanting: Vols. 1–22 (1892-1902), and Vol. 23 to No. 133 (1903).

Mining and Scientific Press.
Wanting: Vols. 1–19 (1860–'69); 24–33, 1872–'76.

Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde.
Wanting: 1830–'38, 1892–date and general index.

New Zealand Mines Record, Wellington, N. Z.
Wanting: Vols. 1–6 (1896-1902).

Queensland Government Mining Journal.
Wanting: Vols. 1–4.

Revue Universelle des Mines, etc., Liége.
Wanting: Series 1; Vols. 1–4 of Series 2 (1857–'78); Vols. 2, 9, 11, 15, and 18 of Series 3. Table des Matières de la première et de la seconde série (1857–'76, 1877–'87).

Société de L'Industrie Minérale. *Bulletin.*
Wanting: Series 1, Vols. 1–15; Series 2, Vols. 1–7.

——— ——— *Atlas.*
Wanting: Pts. 2 of Vols. 11, 13, 14; also Pts. 26–33 of Vol. 2.

——— *Compte Rendu.*
Wanting: Jan. to March, 1879, and July, 1900.

Zeitschrift für Angewandte Chemie.

Wanting: Vols. 1-11 (1887-'99); Vols. 14, 16-17 (1901, 1903-'04).

Zeitschrift für Anorganische Chemie.

Wanting: Vols. 22, 27, 29-38.

R. T. Hill.

Geological History of the Isthmus of Panama and Portions of Costa Rica, in vol. xxviii. of *Bulletin* of Museum of Comparative Zoology. Cambridge.

Geology and Physical Geography of Jamaica, in vol. xxxiv. of *Bulletin* of Museum of Comparative Zoology.

Complete sets of the above publications are greatly needed, as none of them are duplicated in the library of the American Institute of Electrical Engineers or in that of the American Society of Mechanical Engineers.

Please communicate on the above subject with R. W. Raymond, Chairman of the Library Committee, 29 W. 39th St., New York, N. Y.

Accessions.

From Mar. 1 to Apr. 30, 1908.

American Ceramic Society, Columbus, O.

AMERICAN CERAMIC SOCIETY. *Transactions.* Vol. 9. 8vo. Columbus, 1907.

American Institute of Electrical Engineers.

CAMPBELL, W. *The Microscopical Examination of the Alloys of Copper and Tin.* p. 1211-22 il. pl. 8vo. London, 1903.

MUSSEY, H. R. *Combination in the Mining Industry.* 169 p. map. 8vo. New York, 1905.

American Society of Civil Engineers.

AMERICAN SOCIETY OF CIVIL ENGINEERS. *Constitution and List of Members*, 1908. 8vo. New York, 1908.

Art Club of Philadelphia.

ART CLUB OF PHILADELPHIA. *Charter, Constitution, and By-Laws.* 1908.

R. Beck.

BECK, R. *Über die Struktur des Uralischen Plains.* p. 387-96 il. 8vo.

B. H. Brough.

PEDDIE, R. A. *Metallurgical Bibliography*, 1901-1906. 12 p. 8vo. London, Library Supply Co., 1907. Price, 1 shilling.

M. D. Burke.

The Naturalist and the Civil Engineer. A Plea for the Conservation of Natural Forces, and the Betterment of Inland Navigation. 14 p. 8vo. 1908.

Cassell & Co.

GREENWOOD, W. H. and SEXTON, A. H. *Iron and Steel, Their Sources, Varieties, Properties, and Manufacture.* 2 vols. in one, 12mo. London, Cassell & Company, Ltd., 1907.

[SECRETARY'S NOTE.—On another page of this number I have noticed Prof. Sexton's earlier outline of this subject, published in 1902. The present book is a revised and condensed edition of the two well-known little manuals of the late Mr. W. H. Greenwood, on iron and steel respectively. They have been brought down to the date of publication by Prof. Sexton, and bound together in one volume.—R. W. R.]

Colorado Scientific Society, Denver.

COLORADO SCIENTIFIC SOCIETY. *Constitution and By-Laws,* 1907. 12mo. Denver, 1907.

Conservatoire National des Arts et Métiers.

FRANCE—MINISTÈRE DE COMMERCE ET DE L'INDUSTRIE. *Catalogue Officiel des Collections du Conservatoire National des Arts et Métiers.* Pts. 3 and 5. 8vo. Paris, 1908.

W. M. Courtis.

Mining and Scientific Press. Vols. 34–40. 4 v. 8vo. 1877–1879.

Anton Eilers.

Berg- und Huettenmaennische Zeitung. 1869, '70, '71, '76, '77, '78, '79, '80, '81, '83, '84, '86.

Engineering and Mining Journal. Vols. 42, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 55, 56, 57, 59. From July 9, 1886, to June 29, 1895.

Jahrbuch für Berg- u. Huettenwesen. 1886–'90 and 1894.

Mineral Industry. Vols. 1–2, 4, 7, and 10. 1892–'94, '96–'98 and 1901.

U. S.—GEOLOGICAL SURVEY. *Mineral Resources of United States.* 1892–'93 and 1900.

——— *Annual Reports.* 1894–'95, pts. 3–4 (2 Vols.); 1895–'96, pt. 3 (4 Vols.); 1896–'97, pt. 5, 1899, Vol. 6.

Engineering and Mining Journal.

DIETRICH, MAX. *Der Moderne Dampfkessel der Kriegs und Handelsschiffe.* . . . 2 pts. 8vo. Rostock i. M., 1908.

Engineering and Mining Journal.

FERCHLAND, P. *Die Englischen elektrochemischen Patente.* vii, 176 p. il. 8vo. Halle a. S., 1907.

FINLAND—GEOLOGICAL COMMISSION. *Bulletin* No. 19. 8vo. Helsingfors, 1907.

ILLINOIS—STATE GEOLOGICAL SURVEY. *Bulletin* No. 6. 8vo. Urbana, 1907.

MAINE—BUREAU OF INDUSTRIAL AND LABOR STATISTICS. *Annual Report, 21st.* 8vo. Augusta, 1907.

MARTIN, JUSTICE. *Martin's Mining and Water Cases of British Columbia, with Statutes.* Vol. 2, pt. 2. 8vo. Toronto, 1908.

NEW SOUTH WALES—DEPARTMENT OF MINES AND AGRICULTURE. *Geology.* No. 4. 4to. Sydney, 1907.

——— ——— *Geological Maps.*

NISSENSON, H. and POHL, W. *Laboratoriumsbuch für den Metallhüttenchemiker.* ix, 86 p. 8vo. Halle a. S., 1907.

NORTH DAKOTA—STATE GEOLOGICAL SURVEY. *Biennial Report, 4th.* 8vo. Bismarck, 1906.

PELLAT, H. *Cours d'Electricité.* Vol. 3. vi, 285 p. il. 8vo. Paris, 1908.

PENNSYLVANIA—MINES DEPARTMENT. *Report.* Pts. 1–2, 1906. 8vo. Harrisburg, 1907.

STANSFIELD, ALFRED. *The Electric Furnace, its Evolution, Theory, and Practice.* xi, 211 p. il. 8vo. New York-London, 1907.

U. S.—GEOLOGICAL SURVEY. *Bulletin* Nos. 310, 331. 8vo. Washington, 1907, 1908.

——— ——— *Water Supply and Irrigation Paper.* No. 215. 8vo. Washington, 1908.

U. S.—TREASURY DEPARTMENT. *Annual Report of the Commissioner of Internal Revenue,* 1907. 8vo. Washington, 1907.

UNIVERSITY OF MINNESOTA. *General Catalogue,* 1906, '07. 8vo. Minneapolis, 1907.

UNIVERSITY OF WISCONSIN. *Bulletin.* Science Series, Vol. 3, No. 6. 8vo. Madison, 1907.

VEREIN DEUTSCHER EISENHÜTTENLEUTE in Düsseldorf. *Gemeinfassliche Darstellung des Eisenhüttenwesens.* xvi. 254 p. il. 8vo. Düsseldorf, 1907.

Engineers' Club of Central Pennsylvania.

ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA. *Directory*, 1908.

B. F. Fernow.

Forestry Quarterly. Vols. 1–2; Vol. 3, Nos. 2–4; Vols. 4–5. 8vo. Ithaca, 1902–'07.

F. P. Gamba.

GAMBA, F. P. *Tablas de Coordenadas.* 8vo. Pasto, 1908.

Revista de Ingenieria. Vol. 2, No. 2. Pasto, 1908.

Geological Society of London.

WOODWARD, H. B. *The History of the Geological Society of London.* xix, 336 p. por. 8vo. London, 1907.

Geological Survey of India.

INDIA—GEOLOGICAL SURVEY. *Memoirs.* Vol. 32, pts. 1–3. Calcutta, 1901–'02.

——— ——— *Contents and Index of the First Twenty Volumes*, 1859–1883.

——— ——— *Records, Contents, and Index to* Vols. 1–20, 21–30, 1868–'87, 1887–'97. Calcutta, 1891, 1903.

Geological Survey of Maryland.

MARYLAND—GEOLOGICAL SURVEY. *Report.* Vol. 6. 4to. Baltimore, 1906.

Edward Halse.

HALSE, EDWARD. *A Dictionary of Spanish and Spanish American Mining, Metallurgical, and Allied Terms.* xiii, 380 p. 8vo. London, Charles Griffin & Co., Ltd., 1908.

John Harden.

ADAMS, GEORGE. *Lectures on Natural and Experimental Philosophy.* Vols. 1–5. 8vo. London, 1794.

(Vol. 5 contains index and plates.)

ALABAMA—GEOLOGICAL SURVEY. *Bulletin.* Nos. 2, 3, 4.

——— *Report on the Coal Measures of the Plateau Region of Alabama*, by H. McCalley, 1891.

——— *Report on the Geological Structure of Murphree's Valley and Its Minerals and other Materials of Economic Value.* 1893.

AMERICAN IRON AND STEEL ASSOCIATION. *Directory to the Iron and Steel Works of the United States.* 1888. 8vo. Philadelphia.

AUSTIN, J. B. *Mines of South Australia.* 109 p. map. 8vo. Adelaide, 1863.

John Harden.

BAGOT, ALAN. *Accidents in Mines.* lx, l, 177 p. il. London, 1878.

BOURNE, JOHN. *Handbook of the Steam Engine.* xii, 447 p. il. 8vo. N. T. Appleton & Co., 1865.

BOWEN, ELI. *Coal and Coal Oil, or the Geology of the Earth.* lv, 494 p. 8vo. Philadelphia, J. B. Peterson & Bros., 1865.

DANA, J. D. *Manual of Geology.* Ed. 2, xvi, 828 p. il. pl. map. 8vo. New York, 1874.

DAVIES, D. C. *Treatise on Slate and Slate Quarrying.* xvi, 186 p. 8vo. London, 1878.

——— *Treatise on Metalliferous Minerals and Mining.* xx, 432 p. il. pl. 8vo. London, 1880.

DE KONINCK, L. L. and DIETZ, E. *Practical Manual of Chemical Analysis and Assayings.* xviii, 210 p. il. 8vo. London, 1872.

DE LA BECHE, H. T. *Report on the Geology of Cornwall, Devon, and West Somersetshire.* xviii, 648 p. il. pl. maps. 8vo. London, 1839.

——— *Geological Manual.* viii, 535 p. il. 8vo. Philadelphia, 1832.

——— *Derrick and Drill.* 277 p. map. 8vo. New York, 1865.

FARADAY, PROF. *Lectures on the Non-Metallic Elements.* viii, 293 p. il. 12mo. London, 1853.

FOWLER, J. C. *Collieries and Colliers.* xiv, 352 p. 12mo. London, 1861.

GESNER, ABRAHAM. *Industrial Resources of Nova Scotia.* v. p. pl. map. 8vo. Halifax, 1849.

GREAT BRITAIN—MINE INSPECTOR. *Report.* 1878. f°. London, 1879.

GREAT BRITAIN—MINES AND MINERALS. *Mining and Mineral Statistics of the United Kingdom.* 1886. f°. London, 1887.

GREGORY, OLINTHUS. *Mathematics for Practical Men.* Ed. 2, xii, 427 p. pl. 8vo. Philadelphia, 1868.

GUMMERE, JOHN. *Elementary Treatise on Astronomy.* Ed. 2, 373, 104 p. pl. 8vo. Philadelphia, 1837.

HULL, EDWARD. *Coal-fields of Great Britain.* Ed. 2, xx, l, 277 p. il. 12mo. London, 1861.

John Harden.

JUKES, J. B. *Students Manual of Geology.* xiii, 607 p. il. 12mo. Edinburgh, 1857.

KING, W. H. *Lessons and Practical Notes on Steam, the Steam Engine, Propellers, etc.* Ed. 10, 229 p. il. 8vo. New York-London, 1865.

LARDNER, DIONYSIUS. *The Cabinet Cyclopædia.* viii, 419 p. il. 12mo. London, 1840.

——— *Handbook of Natural Philosophy and Astronomy.* 1st course: *Mechanics, Hydrostatics, Hydraulics, Pneumatics, Sound, Optics.* xxiv, 824 p. il. 12mo. London, 1851. 2d course: *Heat, Common Electricity, Magnetism, Voltaic Electricity.* xvii, 456 p. il. 12mo. London, 1852.

LIEBIG, JUSTUS VON. *Familiar Letters on Chemistry.* Ed. 3, xx, 536 p. 12mo. London, 1851.

LYELL, CHARLES. *Elements of Geology.* Ed. 6, xvi, 794 p. il. 8vo. London, 1865.

LYMAN, B. S. *Topography of the Punjab Oil Region.* 14 p. map. 4to. Philadelphia, 1872.

LYMAN, JOSIAH. *Manual of Protracting Trigonometers.* 77 p. il. 8vo. New York, 1862.

MACFARLANE, JAMES. *Coal Regions of America.* xv, 679 p. il. pl., maps. 8vo. New York, Appleton & Co. 1873.

MICHELL, STEPHEN. *Mine Drainage.* xviii, 277 p. il. pl. 8vo. London, 1881.

MICHIGAN—BUREAU OF LABOR AND INDUSTRIAL STATISTICS. *Annual Report,* 11th. 8vo. Lansing, 1894.

MICHIGAN—COMMISSION OF MINERAL STATISTICS. *Annual Report,* 1st. 8vo. Marquette, 1879.

MICHIGAN—GEOLOGICAL SURVEY. *First Biennial Report of the Progress of, Embracing Observations on the Geology, Zoology, Botany of the Lower Peninsula.* 8vo. Lansing, 1861.

MILLER, HUGH. *Old Red Sandstone.* xxiv, 288 p. pl. 8vo. Boston, 1851.

JACKSON, CHARLES T. *Report on the Geological and Mineralogical Survey of the Mineral Lands of the United States in the State of Michigan.* 1847. p. 371–1215 maps. 8vo. Washington, 1849.

John Harden.

MUSHET, DAVID. *Papers on Iron and Steel, Practical and Experimental.* xvi, 952 p. pl. 8vo. London, 1840.

MUSPRATT, SHERIDAN. *Chemistry, Theoretical, Practical, and Analytical.* 2 vols. Edinburgh-London, n. d.

NEW JERSEY—GEOLOGICAL SURVEY. *Annual Report of the State Geologist.* 1869–'81, '83, '88 and 1901. 8vo. Trenton, 1870–'81, '84–'89, 1902.

——— *Annual Report.* 2d. 1855. 8vo. Trenton, 1856.

NICHOLSON, H. A. *Manual of Palæontology for the Use of Students.* xvi, 601 p. il. 8vo. Edinburgh-London, 1872.

NOVA SCOTIA—DEPARTMENT OF MINES. *Report.* 1903, 1905, 1906. 8vo. Halifax, 1904, 1906, 1907.

OHIO—SECRETARY OF STATE. *Annual Report.* 1877. 8vo. Columbus, 1878.

OHIO—GEOLOGICAL SURVEY. *Report.* Vol. vi. 8vo. Columbus, 1888.

——— *Report of Progress in* 1870, by J. S. Newberry. 8vo. Columbus, 1871.

ONTARIO—ROYAL COMMISSION. *Report of the Ontario Royal Commission on the Mineral Resources of Ontario and Measures for their Development.* xxiv, 566 p. map. 8vo. Toronto, 1830.

OVERMAN, FREDERICK. *Practical Mineralogy, Assaying, and Mining.* 230 p. 16mo. Philadelphia, 1851.

PENNSYLVANIA—MINES INSPECTOR. *Report of Anthracite Coal Regions.* 1884. 8vo. Harrisburg, 1885.

PERCIVAL, J. G. *Report on the Geology of the State of Connecticut.* 495 p. map. 8vo. New Haven, 1842.

PERCY, G. M. *Mechanical Engineering of Collieries.* Ed. 2, vol. 1, xxix, 231 p. pl. 8vo. London, 1883.

PIGGOT, A. S. *Chemistry and Metallurgy of Copper.* 388 p. 8vo. Philadelphia, 1858.

RAYMOND, R. W. *Mines of the West.* 256 p. 8vo. New York, 1869.

SAFFORD, J. M. *Geology of Tennessee.* xi, 550 p. il. pl. 8vo. Nashville, 1869.

SHEPARD, C. U. *Treatise on Mineralogy.* Ed. 2, viii, 331 p. il. 12mo. New Haven, 1844.

John Harden.

SMILES, SAMUEL. *Industrial Biography.* 410 p. 8vo. Boston, 1869.

SMYTH, W. W. *Coal and Coal-Mining.* vi, 253 p. 8vo. London, 1869.

TAYLOR, R. C. *Statistics of Coal.* Ed. 2, 640 p. il. map. 8vo. Philadelphia, 1855.

THOMSON, THOMAS. *Outlines of Mineralogy, Geology, and Mineral Analysis.* 2 vols. 8vo. London, 1836.

TYSON, P. T. *Geology and Industrial Resources of California.* xxxiv, 127 p., maps. 8vo. Baltimore, 1851.

SUTRO, ADOLPH. *Mineral Resources of the United States and the Importance and Necessity of Inaugurating a Rational System of Mining with Special Reference to the Comstock Lode and Sutro Tunnel in Nevada.* 232 p. map. 4to. Baltimore, 1868.

U. S.—COMMITTEE ON MINES AND MINING. *Report of the Commissioners and Evidence taken by the United States Committee in Regard to the Sutro Tunnel.* iv, 66, 988 p. 8vo. Washington, 1872.

WILLIAMS, F. S. *Our Iron Roads, their History, Construction, and Social Influences.* xi, 390 p. il. 8vo. London, 1852.

Institution of Civil Engineers, London.

INSTITUTION OF CIVIL ENGINEERS. *Proceedings.* Vol. 170. 8vo. London, 1907.

Institution of Mining and Metallurgy.

INSTITUTION OF MINING AND METALLURGY. *Bulletin* No. 43. 8vo. London, 1908.

Illinois, State Geological Survey.

WELLER, STUART. *The Geological Map of Illinois.* Ed. 2, 34 p. 8vo. Urbana, 1907. (*Bulletin* No. 6.)

J. V. Lewis.

LEWIS, J. V. *Copper-Deposits of the New Jersey Triassic.*

——— *The Origin and Relations of the Newark Rocks.*

——— *The Newark (Triassic) Copper Ores of New Jersey.*

——— *Properties of Trap Rock for Road Construction.* Reprint.

——— *Structure and Correlation of Newark Trap Rocks of New Jersey.* Reprint.

Macmillan and Company, London.

ARNOLD, J. O. and IBBOTSON, F. *Steel Works Analysis.* Ed. 3. xiv, 468 p. il. pl. 8vo. London-New York, 1907. Price, $3.50 net.

[SECRETARY'S NOTE.—In 1894, Prof. John Oliver Arnold, of Sheffield, issued the first edition of this manual of analytical methods. Five years later, a second edition was printed to supply the demand of steel-works chemists; but it presented no changes except the correction of some clerical errors and misprints. But this third edition has been revised by the author, with the aid of Mr. Ibbotson, so as to cover the great advances in the metallurgy of steel, and in the functions and methods of the steel-works laboratory, which have characterized the last decade. In this work it has been necessary, as the author explains, to drop the description of obsolete operations, and to insert that of new rapid methods, or of improvements in the accuracy of former ones. Among the most important subjects thus freshly treated are gas-analysis, the calorimetry of fuels, and the analysis of brasses, bronzes, white metals, and high-speed steels. The book retains the feature which made the first edition so useful—namely, it is not a catalogue of methods, good, bad, and indifferent, presented without comment, but a critical guide to the practitioner in his choice.—R. W. R.]

Municipal Engineers of the City of New York.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. *Constitution, By-Laws, List of Members, and Annual Report,* 1907. 8vo. New York, 1908.

S. M. Pitman.

BOSTON SOCIETY OF CIVIL ENGINEERS. *Report of Standing Committee on the Metric System of Weights and Measures.* December, 1876. 8vo. Boston, 1876.

CAMBRIDGE WATER BOARD. *Annual Report of . . . to the City Council, 12th.* 8vo. Boston, 1876.

CHATARD, T. M. *On Some New Analytical Methods.* 4 p. 8vo. n. p., n. d. (Reprint.)

CLARK, J. E. *On the Triassic Boulder, Pebble, and Clay Beds at Sutton, Coldfield, near Birmingham.* 8 p. pl. 8vo. n. p., 1878.

CLARKE, F. W. and STALLO, HELENA. *The Constitution of the University of Cincinnati.* 13 p. 8vo. n. p., n. d. Reprint.

COOKE, J. P. *Memoir of Thomas Graham.* n. p., 1870. (2 copies.)

COUTIE, WILLIAM. *Natural Philosophy and Modern Chemistry.* 11 p. 8vo. Troy, 1876.

DEUTSCHE CHEMISCHE GESELLSCHAFT. *Berichte.* Years, 7–13. 8vo. 1874–1880.

S. M. Pitman.

DOLBEAR, A. E., PROF. *Researches in Telephony.* 8vo. n. p., 1878. Reprint. (2 copies.)

——— *Sound Vibrations and the Telephone.* 11 p. 8vo. New York, 1879.

——— *Examination Questions on Chemical Philosophy.* 24 p. 8vo. n. p., n. d.

FOLSOM, O. F. *The Present Aspect of the Sewage Question as Applied to Boston.* 18 p. 8vo. Boston, 1877.

GIBBS, WOLCOTT. *A Simple Method of Avoiding Observations of Temperature and Pressure in Gas Analyses.* 6 p. 8vo. n. p., n. d. (Reprint.)

——— *Researches on the Complex Inorganic Acids.* 21 p. 8vo. n. p., n. d.

GLASER, CARL. *Ueber einen neuen Gasofen zur Elementaranalyse.* 8 p. 8vo. Bonn, 1870.

HARRIS, W. T. *Method of Study in Social Science.* 23 p. 8vo. St. Louis, 1879.

HILL, H. B. *On the Ethers of Uric Acid.* 11 p. 8vo. n. p., n. d. Reprint.

——— and MABERY, O. F. *On the Ethers of Uric Acid, Second Paper.* 8vo. n. p., n. d.

HILLEBRAND, DR. und NORTON, DR. *Ueber Metallisches Cer, Lanthan und Didym.* 8vo. n. p., n. d.

HILLS, E. R. *Schweinfurt Green.* 8vo. n. p., n. d.

JACKSON, C. L. *Researches on the Substituted Benzyl Compounds.* (Contributions from the Chemical Laboratory of Harvard College. Nos. iii, vii, xv (2 copies), xvii, and xviii.)

JOHNSON, S. W. *Chemical Notation and Nomenclature Old and New.* 6 p. 8vo. New York, 1871.

KESSLER, F. *Ist das Atomgewicht des Antimons* (Sb) 120 *oder* 122? 23 p. 8vo. Bochum, 1879.

MUNROE, C. E. *The Estimation of Manganese as Pyrophosphate.* 12 p. 8vo. New York, 1877.

——— *On the Estimation of Phosphoric Acid.* 10 p. il. 8vo. n. p., n. d. Reprint.

NORTH CAROLINA—AGRICULTURAL EXPERIMENT STATION. *Annual Report,* 1879. 8vo. Raleigh, 1879.

SHARPLES, S. P. *Milk Analysis.* 7 p. 8vo. Philadelphia, 1876.

S. M. Pitman.

SHARPLES, S. P. *Scheele's Green, Its Composition as Usually Prepared, and Some Experiments upon Arsenite of Copper.* 8vo. n. p., n. d. Reprint.

——— *On Some Forms of the Galvanic Battery.* 8vo. n. p., n. d. Reprint. (3 copies.)

Polytechnic Institute of Brooklyn.

POLYTECHNIC INSTITUTE OF BROOKLYN. *Catalogue of the College of Engineering,* 1908–'09.

Redfield College.

The Sioux. Vol. 20, Nos. 4 and 5. 8vo. Redfield, 1908.

T. A. Rickard.

RICKARD, T. A. *Journeys of Observations.* v. p. il. 8vo. San Francisco, 1907.

[SECRETARY'S NOTE.—This is practically two books. The first is the description of a journey from New York to Mexico, together with a description of the mining industry of El Oro, Pachuca, and Guanajuato, as observed in October, 1905, compiled from articles in the *Mining and Scientific Press;* and the second is the account of a ride over the mountainous regions of Southern Colorado, in 1902, compiled from articles in the *Engineering and Mining Journal.* Both have a literary as well as professional value which justifies their reproduction in this permanent form. The discussion of modern metallurgical practice in Mexico—especially in the use of the cyanide process, which is, perhaps, more modern and more important in Mexico than anywhere else—is an extremely valuable contribution to technical literature. Mr. Rickard's descriptions of scenery, people, and customs are graceful and picturesque; and the mechanical excellence of the book in paper, print, and illustrations does credit to the Pacific Coast publishers and craftsmen.—R. W. R.]

Rollins College.

ROLLINS COLLEGE. *Bulletin.* Vol. 1, No. 4. 8vo. Winter Park, 1908.

A. H. Sexton.

SEXTON, A. H. *An Outline of the Metallurgy of Iron and Steel.* 16, 620, 13 p. il. 8vo. Manchester Publishing Co., Manchester, Eng., 1902.

[SECRETARY'S NOTE.—The author of this work occupies the chair of metallurgy in the Glasgow and West of Scotland Technical College, and is a past-President of the West of Scotland Iron and Steel Institute. It follows that his treatise, though avowedly only a selected compilation from modern technical literature, should command respectful attention. Indeed, it seems to be one of the best summaries of present theory and practice which are now available to English and American readers. Authoritatively final it can hardly be called; for the author has used his critical knowledge rather in the selection than in the judicial approval or condemnation of modern hypotheses. But, after all, how can any of us expect the final statement of the science or the art of iron and steel metallurgy?

All that we can do is to buy the last good book on the subject, with the regretful consciousness that we shall be obliged, before long, to buy another! In which lamentable situation, I think we would all do well to acquire Prof. Sexton's volume.—R. W. R.]

Society of Naval Architects and Marine Engineers.

Constitution, By-Laws, List of Members, 1908. 16mo. New York, 1908.

Dr. Joseph Struthers.

CHAPMAN, R. H. *A Drowned Empire.* 8vo. Washington, 1908. (Reprint.)

Cobalt Lake Controversy. 16 p. 8vo.

LILIENBERG, N. *The Compression of Semi-Liquid Steel Ingots.* p. 121–140 pl. 8vo. Philadelphia, 1908.

MUNDY, F. W. *The Earning Power of Railroads*, 1908. 376 p. 8vo. New York, J. H. Oliphant & Co., 1908.

U. S.—INTERIOR DEPARTMENT. *Examinations for the Drainage of Lands made by* . . . 16 p. 8vo. Washington, 1908.

Map of the United States, Showing Areas Surveyed, Scattered, Swamp, Solid Swamp, River Surveys, and Location of Gaging Stations. Plate No. 11.

Map of Part of Sacramento Valley, California. (Sheet M.)

Map of Klamath Project, Oregon-California.

Map of Clarksdale, Mississippi.

Drainage Plan of Mud Lake District, Minnesota.

Williamston Sheet, North Carolina.

Syracuse Sheet, New York.

Technical World Magazine.

MARKS, L. S. and WYER, S. S. *Gas-Engines and Producers.* iv, 6, v p. 8vo. Chicago, 1902.

University of Nebraska.

UNIVERSITY OF NEBRASKA. *The Nebraska Blue Print.* Vols. 1–6. 8vo. Lincoln, 1902–'07.

——— ——— *University Studies.* Vols. 1, 2, and 3–7. 8vo. Lincoln, 1888–1907.

University of Pennsylvania.

UNIVERSITY OF PENNSYLVANIA. *Proceedings of "University Day,"* Feb. 22, 1908. 8vo. Philadelphia, 1908.

U. S.—Interstate Commerce Commission.

U. S.—INTERSTATE COMMERCE COMMISSION. *Annual Report, 21st.* 8vo. Washington, 1907.

U. S.—Interstate Commerce Commission.

U. S.—INTERSTATE COMMERCE COMMISSION. *Annual Report on the Statistics of Railways, 19th.* 8vo. Washington, 1907.

United States Steel Corporation.

UNITED STATES STEEL CORPORATION. *Annual Report, 6th.* 4to. Hoboken, 1907.

D. Van Nostrand Co.

Monthly Record of Science Literature. Vols. 28–30. January, 1903, to August, 1907. 8vo. New York, 1907.

Friedr. Vieweg and Sohn.

WEDDING, DR. HERMANN. *Ausführliches Handbuch der Eisenhüttenkunde.* Vol. 4, pt. 2. Die Gewinnung des Schmiedbaren Eisens aus Roheisen. 8vo. Braunschweig, F. Vieweg and Sohn, 1908. Price, 16 marks.

[SECRETARY'S NOTE.—Since the reception from Councilor Wedding's publishers of this latest instalment of his great work on the metallurgy of iron, we have learned by cable of his death. This is not the appropriate place for the expression, either of personal sorrow or of professional eulogy, both of which will doubtless find utterance in our *Transactions* hereafter; but I may not improperly here declare both my regret that Dr. Wedding did not live to finish and revise his monumental treatise, and also my gratitude that he was spared to us long enough to perform so large a part of that work. This last instalment treats of the production of malleable or wrought-iron from pig-iron, including the processes of refining, puddling, cementation, etc., all of which, though temporarily, and more or less completely, eclipsed by the converter and the open-hearth, now appear to have been by no means extinguished, and are again claiming the attention of metallurgists and manufacturers.—R. W. R.]

Wallaroo & Moonta Mining & Smelting Company, Ltd.

WALLAROO & MOONTA MINING & SMELTING COMPANY, LTD. *Reports and Statements of Accounts, 18th Annual Report.* 4to. Adelaide, 1907.

John Wiley & Sons.

BEARD, J. T. *Mine Gases and Explosions.* Text-Book for Schools and Colleges. xvii, 402 p. il. 12mo. New York, John Wiley & Sons, 1908. Price, $3.00.

[SECRETARY'S NOTE.—This text-book is likely to be useful not only to the students for whom it is intended, but also to engineers in practice. The author is the director of the coal-mining department of the Scranton International Correspondence Schools, an associate editor of *Mines and Minerals*, and a member of various leading technical societies, at home and abroad. He is also favorably known as the author of a book on the ventilation of mines, published in 1894, and of many articles upon cognate subjects. His present work is a clear, compact and up-to-date résumé of the theory and literature of its important theme.—R. W. R.]

John Wiley & Sons.

KARAPETOFF, V. *Experimental Electrical Engineering and Manual for Electrical Testing.* xxxi, 790 p. il. 8vo. New York, 1908. Price, $6.00.

[SECRETARY'S NOTE.—This book, by an instructor at Cornell University, is intended to be a laboratory manual of such practice in electrical engineering as is required, during the last two years of the course, in most of our American technical schools. Some years ago, it could be truly said that there were two sciences of electricity, one which was stated in the text-books, while the other (and far more advanced) was known in the shops and laboratories of practitioners, manufacturers, and inventors. It was not possible that this distinction could long continue; and such manuals as this are rapidly abolishing it, by bringing the latest results of experience into the systematic form and relations which make them part of science. Besides presenting a multitude of principles, facts, and suggestions, Mr. Karapetoff's book sets forth and advocates a special method (which he calls the "concentric" method) of instruction. Without presuming to pronounce judgment in this special department, I may say frankly that I think the author's arguments in favor of this system are sound. Moreover, knowing that analogous methods have proved to be the best in the teaching of mathematics, languages, etc., I feel sure that he is right. One caution, however, must be given. The "concentric" system must be judged by its final result. A student who stops in the middle of a course thus conceived will be a smatterer. But this subject is too large for thorough discussion here; and I will add only, that the author's arguments are worthy of the serious attention of all technical instructors, and that, whether his view in this respect be right or wrong, his book is a useful one.—R. W. R.]

NORRIS, H. H. *An Introduction to the Study of Electrical Engineering* v, 404 p. il. 8vo. New York, 1907. Price, $2.50 net.

[SECRETARY'S NOTE.—This excellent manual, like almost all up-to-date text-books, is the product of a teacher's experience. The author is the Professor of Electrical Engineering at Sibley College, Cornell University; and his book evidently comprises that general survey and summary of the subject which must be the basis of instruction in the lecture-room and the laboratory. It is absurd to require that a professor shall, year after year, mechanically repeat, and that his class, in more or less correct notes, shall annually take down, the statements of fundamental facts and principles. Every such instructor worthy of his work will ultimately make or adopt, for his own use, a printed synopsis which will save, to himself and his students alike, the precious time needed for further inquiries, comments, and explanations, besides furnishing a convenient standard for measuring the intelligence and industry of students. This work has been well done by Prof. Norris, and his book, which will doubtless serve the convenience and profit of many successive classes of his own, may be used with advantage by other instructors also. Moreover, it presents to general readers an admirable picture of the work and sphere of the electric current in modern civilization, in the distribution of mechanical power, the production of light and heat, the transmission of language, and the electrolytic treatment of metallic compounds.—R. W. R.]

John Wiley & Sons.

BETTS, A. G. *Lead Refining by Electrolysis.* ix, 394 p. il. pl. 8vo. New York, 1908. Price, $4.00.

[SECRETARY'S NOTE.—At the Albany Meeting of the Institute, in February, 1903, the author of this book presented a paper (*Trans.*, xxxiv., 175) on electrolytic lead-refining, which at once established his position as an authority on that subject. The application to this particular operation of a method already established in the metallurgy of copper had been proposed before, as, for instance, in 1884, by Mr. N. S. Keith (*Trans.*, xiii., 310); but, for some reasons of difficulty in practice, which I cannot here discuss, had not come into general commercial use. Mr. Betts seems to have overcome these difficulties; and the detailed discussion of his method, which appears in this volume together with descriptions of two important plants, in the United States and in British Columbia respectively, which are successfully using it, will be instructive and welcome to all metallurgists.—R. W. R.]

David Williams Company.

FORSYTHE, ROBERT. *Blast Furnace and Manufacture of Pig-Iron.* 368 p. 8vo. New York, 1908.

[SECRETARY'S NOTE.—The author of this book, born in 1869, and graduated at Harvard in 1895, was subsequently for three years instructor in metallurgy at that university, and then engaged, until his death in 1907, in metallurgical practice in the open-hearth and blast-furnace departments of the Pennsylvania Steel Co., at Steelton, Pa., and the Tide-water Steel Co., at Chester, Pa. At the time of his death this work was already in proof, and it is published without his final corrections, though not without the careful revision of a friend. According to the author's preface, it was designed to be, not an exhaustive treatise on the subject, but a summary for the use of beginners. The theory and art of blast-furnace management have been so thoroughly revolutionized within recent years as to call unquestionably for new treatises on the subject. Mr. Forsythe has met this demand to a considerable degree, though the comparatively small size of his book did not permit a complete re-treatment of its theme. It is, however, practically up-to-date; it contains references to recent literature which will guide the reader in further research; and therefore it must be useful, as a modern, intelligent, and comprehensive summary, to all students or practical operators in the metallurgy of iron and steel.—R. W. R.]

NEW EXCHANGES.

American Fertilizer. Monthly. Vol. 28-date. 4to. Philadelphia, 1908-date. Yearly subscription, $2.00 (domestic), $2.50 (foreign). Single copies, 25c.

Clay Worker. Official Organ of the National Brick Manufacturers' Association. Monthly. Vol. 49-date. 4to. Indianapolis, 1908-date. Yearly subscription, $2.00.

Forestry Quarterly. 8vo. Ithaca, 1902-date. Yearly subscription, $2.00.

Industrial Japan. Monthly. Vol. 5-date. 4to. Chicago, 1908-date. Subscription, 8s.; single copies, 10d.

Metal Worker, Plumber, and Steam Fitter. Weekly. Vol. 69-date. 4to. New York, David Williams Co., 1908-date. Yearly subscription, $2.00; single copies, 5c.

ROYAL INSTITUTE OF BRITISH ARCHITECTS. *Journal.* Quarterly. Series 3, Vol. 15-date. 4to. London, 1907-date.

Science and Art of Mining. Quarterly. Vol. 18, No. 16-date. 4to. Wigan, 1908-date. Single copies, 3d.

SOCIÉTÉ BELGE DE GÉOLOGIE DE PALÉONTOLOGIE ET D'HYDROLOGIE.

SOCIÉTÉ CHIMIQUE DE BELGIQUE.

Zeitschrift für das Gesamte Schiess-Sprengstoffwesen. Bi-Weekly. Year, 3-date. 4to. München, 1908-date. Yearly subscription, 26 marks; single copies, 1 mark.

PURCHASES.

Skinner's Mining Manual. 1908. 8vo. London, 1908.

Stevens' Copper Handbook. Vol 7. 8vo. Houghton, Mich. Horace J. Stevens, 1908.

SOCIETY OF CHEMICAL INDUSTRY. *Decennial Index of the Journal.* Vols. 15–24, 1896–1905. 4to. London, Vacher, 1907.

LEDEBUR, A. *Handbuch der Eisenhüttenkunde.* Ed. 5. 8vo. Leipzig, A. Felix, 1906–'08.

TRADE CATALOGUES.

Realizing the value of trade catalogues in a technical library, the Library Committee of the American Institute of Mining Engineers has signified its approval of a plan to strengthen the library along this line. Manufacturers are therefore asked to place the Library of the American Institute of Mining Engineers on their regular mailing-lists for Trade Catalogues on Metallurgical and Mining Machinery, Mine and Miners' Supplies, Metallurgical Laboratory Equipments, Assayers' and Chemists' Supplies, etc., and also Technical Industrial Catalogues.

All contributions will be acknowledged in the *Bi-Monthly Bulletin.*

AMERICAN STEEL PUMP COMPANY, Battle Creek, Mich. Marsh Boiler Feed Pumps. (Form 314.)

AVERY MANUFACTURING COMPANY, Peoria, Ill. Thresher Supply Catalogue. Engines, Threshers, Steam Plows. 1907.

BRODERICK & BASCOM ROPE COMPANY, St. Louis. Transportation of Clay by an Aërial Wire Rope Tramway.

——— *Yellow Strand.* Vol. 7, No. 5.

——— Souvenir 27th Annual Convention of the Iowa Brick and Tile Association, Des Moines, Iowa.

BRUCE-MERIAM ABBOTT COMPANY, Cleveland, Ohio. Vertical Gas-Engines for Electric Lighting, Pumping, and General Power Purposes. (Catalogue A, Section 1, 1908.)

COATESVILLE BOILER WORKS, Coatesville, Pa. Plate Metal Construction.

CONNERY & COMPANY, LTD., 1326 North Ninth St., Philadelphia, Pa.. Steel Plate Construction, Chimneys, Stand-Pipes, and Flue Connections.

CYCLONE DRILL COMPANY, Orrville, Ohio. *The Drill Hole.* Vol. 2, No. 3. March, 1908.

FOOTE MINERAL COMPANY, 107 North Nineteenth St., Philadelphia, Pa. Catalogue of Elementary Collections. Contains a Systematic Classification, giving Crystallographic Form and Chemical Composition of all Known Minerals.

THE GARDNER PRINTING COMPANY, Cleveland, Ohio. Castings Directory, 1908.

GENERAL ELECTRIC COMPANY, Schenectady, N. Y. General Electric Fan Motors. January, 1908.

——— Tantalum Incandescent Lamps.

——— Isolated Plant Switchboard Panels with Fuses.

——— The Tungsten Lamp for Street Series Lighting.

——— General Electric Carbon Break Circuit-Breakers, Type C, Forms G, P, and K.

——— Thomson Horizontal Edgewise Instruments, Type H, for Switchboard Service.

——— Direct-Current Motor Starting Devices, Rheostats, and Panels, Mill Type Motors.

——— Centrifugal Air Compressors for Industrial Air-Blast and Exhauster Service.

GENERAL ENGINEERING COMPANY, Salt Lake City, Utah. Ore-Testing Bulletin.

GOLDSCHMIDT THERMIT COMPANY, 90 West St., New York, N. Y. Butt Welding Wrought-Iron and Steel, Pipes, and Rods, by the Thermit Process.

——— *Reactions.* A Quarterly Publication Devoted to the Science of Aluminothermics. 1908.

GREENE, F. C., Republic Building, Cleveland, Ohio. Greene System of Self-Dumping Car Haul.

——— Greene System of Handling and Dumping Mine Cars.

GROTHE & CARTER, Mexico City, Mexico. Improvements in Cyaniding Practice. Agitation by Means of Compressed Air in the Pachuca Tank. Mexico City, 1908.

HOCKENSMITH WHEEL & MINE CAR COMPANY, Penn Station, Pa. Catalogue.

INGERSOLL-RAND COMPANY, 11 Broadway, New York, N. Y. Air and Gas Compressors. (Catalogues Nos. 36, A 36, H 36, R 37.)

——— Davis Calyx Diamondless Core Drill. (Catalogue No. 91.)

——— Small Power-Driven Air-Compressors. (Catalogue No. E 36.)

——— Small Steam-Driven Air-Compressors. (Catalogue No. F 36.)

——— Stone Channelers. (Catalogue No. 60.)

——— Temple-Ingersoll Electric-Air Rock-Drill. (Catalogue No. 20.)

——— Water Lifted by Compressed Air. (Catalogue No. 73.)

——— Pumping by Compressed Air. (Catalogue No. 12.) Pneumatic Engineering Company.

JEFFREY MANUFACTURING COMPANY, Columbus, Ohio. Jeffrey Mine Equipment.

NEW YORK FLEXIBLE METALLIC HOSE AND TUBING COMPANY, 177 Lafayette St., New York, N. Y. (*Bulletin* Nos. 25, 26.)

——— Metallschlauch Fabrik Pforzheim, vorm. Hch. Witzemann, Baden, 1906.

PETERBOON & SCHURMANN, Düsseldorf, Germany. Westdeutsche Apparate Bauanstalt. 1908.

PNEUMELECTRIC MACHINE COMPANY, Syracuse, N. Y. Electric Coal Puncher.

PRESCOTT STEAM PUMP COMPANY, Milwaukee, Wis. Pumping Engines, Steam Pumps, and Condensing Apparatus. (Catalogue No. 20.)

SCHIEREN, C. A. & COMPANY, Schieren Building, New York, N. Y. *Belt Book.* A Magazine for Users of Belting. January, 1908.

STEPHENSON-ADAMSON MANUFACTURING COMPANY, Aurora, Ill. Conveying and Transmission, Vol. 4, Nos. 2 and 3.

STRONG, CARLISLE & HAMMOND COMPANY, Cleveland, Ohio. Squires Steam Specialties.

TRENT ENGINEERING & MACHINERY COMPANY, Salt Lake City, Utah. Monadnock Mill. (Circulars Nos. 191 and 181 A.)

Western Machinery. Monthly Magazine Devoted to the Mining and General Machinery and Supply Buyers in the West, The British Northwest, and Old Mexico. Vol. 1, No. 2. 4to. Denver, Western Machinery Publishing Co., 1908.

MEMBERSHIP.

The following list comprises the names of those persons elected as members or associates, who accepted election during March and April, 1908:

MEMBERS.

Clifford D. Caldwell,	Pennington Gap, Va.
John Henry Dowe,	London, England.
Erminio Ferraris,	Monteponi, Sardinia, Italy.
William Gummere,	Roebling, N. J.
D. F. Haley,	West Gore, N. S., Can.
H. B. Tancred Hawkins,	Ballydehob, Ireland.
Roy J. Holden,	Blacksburg, Va
Reginald E. Hore,	Ann Arbor, Mich.
George A. Howells,	New York, N. Y.
Archibald J. Hunt,	Ojuela, Mapimi, Durango, Mex.
Clements F. V. Jackson,	Brisbane, Queensland, Aust.
Edward F. Kenney,	Johnstown, Pa.
Shun Tet Kong,	Honolulu, Hawaii.
John E. Leibfried,	Chicago, Ill.
Duncan F. McAulay,	Cobar, N. S. W., Aust.
Samuel D. McMiken,	Komata, Auckland, N. Z.
Robert Marsh, Jr.,	Kimberly, Nev.
Samuel H. Richardson, Jr.,	Republic, Wash.
Walter E. Segsworth,	Toronto, Can.
Robert Smart,	White Horse, Y. T., Can.

ASSOCIATES.

Joseph B. Elwell,	New York, N. Y.
Desaix B. Myers,	Boston, Mass.
James M. Raine,	South Bethlehem, Pa.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members or associates of the Institute during March and April, 1908. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

MEMBERS.

Louis K. Acker, Jr.,	Bellevue, Pa.
Guillermo A. Alamos,	Rapid City, So. Dak.
E. A. Austin,	Dawson, Y. T., Can.
Augustus Ellsworth Bachert,	Robertsdale, Pa.
Egbert Henry Ballard,	Everett, Mass.
Tracy Bartholomew,	Denver, Colo.
Jules R. Breuchaud,	Guanajuato, Mex.
Alfred Brown,	Wallaroo, So. Aust.
Hyacinthus Paul Civretto,	Unsan, Korea.
Walter Belt Cole,	Yucca, Ariz.
Harry McKean Conner,	Prince, W. Va.
C. V. Corless,	Victoria Mine, Ont., Can.
Edmund J. D. Coxe,	Houtzdale, Pa.
James Chambers Dick,	Salt Lake City, Utah.
Edgar Varick Dodge,	Bagdad, Cal.
John Herbert Farrell,	Marquette, Mich.
Joseph Henry Frantz,	Columbus, O.
Lee Fraser,	Saginaw, Mich.
Henry S. Geismer,	Sayreton, Ala.
Chester H. Graves,	Tecumseh, Ala.
Thomas Bevil Greenfield,	Spassky Zavod, Akmolinsk, Siberia.
George T. Hausen,	Milwaukee, Wis.
Joseph G. Hibbs,	Philadelphia, Pa.
C. Barnes Hoadley,	Wickenburg, Ariz.
Frederick W. Horton,	Somerville, Mass.
Tatsuzo Kamiyama,	Iburi, Hokkaido, Japan.
Ross Dayton McCausland,	Chihuahua, Mex.
Thomas W. Mather,	Guayaquil, Ecuador, So. Amer.

Robert Breck Moran, ... San Francisco, Cal.
Frederick B. Nold, ... Hondo, Coah., Mex.
Bartolomé Novoa, ... Collahuasi, Chile, So. Amer.
Ignacio Diaz Ossa, ... Rapid City, So. Dak.
George Washington Otterson, ... Seattle, Wash.
William D. Owens, ... Pittston, Pa.
Harry G. Palsgrove, ... Ciénegas, Coah., Mex.
Henry Martin Parks, ... Corvallis, Ore.
Henry H. Patterson, ... Newark, Cal.
Hugh F. K. Picard, ... London, England.
James Pryor, ... Wallaroo, So. Aust.
Charles Henry Purcell, ... Cerro de Pasco, Peru, So. Amer.
Bertram D. Quarrie, ... Cleveland, O.
Levi E. Riter, Jr., ... Salt Lake City, Utah.
Walter Maxwell Henderson Scott, ... Smuggler, Colo.
Alexander Carlaw Scoular, ... Ellerslie, Whitehaven, England.
Douglas B. Sterrett, ... Washington, D. C.
Benjamin F. Tibby, ... Salt Lake City, Utah.
Charles Edward Turner, ... Valverde del Camino, Huelva, Spain.
Harry Leonard Venables, ... Oxford, England.
Robert Ernest Blackadder Vinicombe, . . . Spassky Zavod, Akmolinsk, Siberia.
Edwin Richard Wash, ... Yerington, Nev.
W. P. White, ... Moyie, B. C., Can.
Mauji Yoshimura, ... Marunouchi, Tokio, Japan.
Howard Patterson Zeller, ... Las Esperanzas, Coah., Mex.

ASSOCIATES.

Tetsutaro Hasegawa, ... New York, N. Y.
Karl Almon Pauly, ... Schenectady, N. Y.
Louis Harry Winkler, ... Johnstown, Pa.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the period of Mar. 1 to May 1, 1908. This list, together with the list in *Bi-Monthly Bulletin*, No. 20, March, 1908, therefore, supplements the annual list of members corrected to Jan. 1, 1908, and brings it up to the date of May 1, 1908. The names of Members who have accepted election during March and April, 1908 (new members), are printed in *italics*.

By a simple method of cutting out these names and addresses, and pasting them directly over the corresponding names in the annual list of members, the record can be kept practically up to date and the value of the list correspondingly increased. For this purpose the changes of address have been printed only on one side of the page. The names of new members, being in italics, are readily distinguished from the others, and can be pasted in approximate alphabetical order on the margins of the pages of the list.

AARONS, J. BOYD........................20 Gresham House, London, E. C., England.
ABE, MASAYOSHI, Prest. of the Meiji Seiren Kaisha (Meiji Smelting Co.), Imabashi 3 chome, Osaka, Japan.
ADAMS, WILLIAM.....................................Apartado 283, Chihuahua, Mexico.
ADAMS, WILLIAM H.........................Griffiths Co., Alaska Bldg., Seattle, Wash.
AERTSEN, GWILLIAEM, Railway Steel-Spring Co., 30 Church St., New York, N. Y.
AFFLECK, WILLIAM, Care James W. Ellsworth & Co., Rockefeller Bldg., Cleveland, Ohio.
ARMAS, MILTIADES TH..............Casilla, No. 327, La Paz, Bolivia, So. America.
ARMSTRONG, THOMAS...............................1011 West Adams St., Phœnix, Ariz.
ASHMORE, ERNEST P., Min. Engr., 109 Lansdowne Place, Hove, Sussex, England.
ATKIN, AUSTIN J. R., Steynsdorp, via Kemati River, Barberton, Transvaal, So. Africa.
AUSTIN, W. LAWRENCE...................................P. O. Box 1061, Riverside, Cal.
BABBITT, THOMAS D...Nampa, Idaho.
BACON, DON H...109 East 39th St., New York, N. Y.
BARNETT, WILLIAM J., Cons. Min. Engr., 442 Salisbury House, London Wall, London, E. C., England.
BECK, EDWIN L...Whitcomb, Mont.
BECKER, THEODORE............................ Garfield Smelting Co., Garfield, Utah.
BELL, J. MACKINTOSH, Director, New Zealand Geological Survey, Wellington, New Zealand.

BENSON, ALEXANDER..Grosseto, Italy.
BIRD, ROBERT MACDONALD, Care S. Pearson & Son, Ltd.,
47 Parliament St., Westminster, London, S. W., England.
BISHOP, ROY N..Balaklala Copper Co., Coram, Cal.
BLACK, R. S., Genl. Mgr., The Kalgurli Gold Mines, Ltd.,
Boulder, Western Australia.
BLACKMER, WILLIAM D., Care H. M. Blackmer,
49 Exchange Place, New York, N. Y.
BLANDY, S. H. B., Chen dai Lode Syndicate, Lahat, Perak,
Federated Malay States.
BORDEAUX, ALBERT F. J.................................Thonon les Bains, Savoie, France.
BOSCH, ANTON, Met. Engr., Villa L'Hermitage, Vence, Alpes-Maritines, France.
BOSQUI, FRANCIS L....................................819 Mills Bldg., San Francisco, Cal.
BOTSFORD, BOBERT S., The Poderosa Mine, Collahuasi,
Antofagasta, Chile, So. America.
BOWEN, HERBERT P ....Care Hyler & Hyler, Moctezuma, Sonora, Mexico.
BOWMAN, FRANCIS C., Min. and Met. Engr........213 Boston Bldg., Denver, Colo.
BOYLE, EMMET D...Gazette Bldg., Reno, Nev.
BRENNON, JOHN C., Carpenter & Brennon, Min. Engrs.,
519 La Mutua, Mexico City, Mexico.
BROWN, HARVEY S.......................................General Delivery, Tonopah, Nev.
BROWN, JOSEPHUS J., Jr...Blanding, Ill.
BROWNE, ROSS E.. 234 Perry St., Oakland, Cal.
BROWNLEE, ARCHIBALD G..........................503 Colorado Bldg., Denver, Colo.
BUCK, ARTHUR H..2822 Arapahoe St., Denver, Colo.
BURRALL, FREDERICK P...............................Arctic Coal Co., Trondhjem, Norway.
CADMAN, JOHN...The Clough, Newcastle-on-Lynn, North Staffordshire, England.
**Caldwell, Clifford D.*, Prest., Monarch Coal & Coke Co., Pennington Gap, Va. '08.
CAMPHUIS, GEORGE A., Compania Beneficiadora de Metals,
Apartado 57, Pachuca, Mexico.
CARLETON, JAMES G...2 Gregory St., Marblehead, Mass.
CARR, HENRY C., Care Carr & Hibbs, Min. Engrs.,
Penn Mutual Bldg., Philadelphia, Pa.
CARRY, HENRY E. C.................... 1306 Cardero St., Vancouver, B. C., Canada.
CARSON, ELLARD W...................................2142 Thompson St., Los Angeles, Cal.
CARTER, HENRY M....Care Handy & Harman......202 John St., Bridgeport, Conn.
CHENNELLS, J. ARNOTT, Kambove, Care P. O. Kansanshi,
N. W. Rhodesia, So. Africa.
CHISHOLM, JOHN.......................................71 Guilford St., London, W. C., England.
CHURCH, JOHN A., Jr. ....697 West End Ave., New York, N. Y.
CHURCH, JOHN L., Min. Engr..........Tramys Consolidated Mines, Rhyolite, Nev.
CLARK, V. V.............Mgr., Bunker Hill Mining & Smelting Co.. Reiter, Wash.
COCKERELL, L. MAURICE.............Isthmian Club, Piccadilly, London, England.
CODINGTON, E. W., Cons. Engr., Goldfield Granite Mountain Mining Co.,
Santa Monica, Cal.
CRAWFORD, GEORGE G., Prest., Tennessee Coal, Iron & R. R. Co.,
Birmingham, Ala.
DARGIN, PERCY W., Genl. Mgr., Midas Gold Mining Co.,
Midas, via Golconda, Nev.
DE SOLLAR, TENNY C., Min. Engr., Quincy Mining Co.,
P. O. Box 45, Hancock, Mich.
DISSINGER, EARL, Cyanide Supt., Gold Mountain Consolidated Mining Co.,
Kimberly, Utah.

DIXON, ALEXANDER G.................................4429 Delmar Ave., St. Louis, Mo.
DON, JOHN R..............High near Butler St., Maori Hill, Dunedin, New Zealand.
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**Dowe, John H.*, Mine Mgr., 3 Park Mansions, Sydenham Park,
London, S. E., England. '08.
EDWARDS, ROBERT L........Mgr., Kittie Burton Gold Mining Co., Ulysses, Idaho.
ELLARD, HUGH F., Genl. Mgr., Commanche Mining & Smelting Co.,
Silver City, New Mexico.
†*Elwell, Joseph B.*, Author, and Prest., Quibbs Gold Dredging Co.,
640 Madison Ave., New York, N. Y. '08.
ESCHER, FRANK.......... ....Rigistr. 39, Zurich IV, Switzerland.
EYE, CLYDE M........................Baguio, Province of Benguet, Philippine Islands.
**Ferraris, Erminio*, Min. Engr ....Monteponi, Sardinia, Italy. '08.
FINCH, JOHN W..Instructed to hold all mail.
FISHER, WILLIAM B............................318 Herald Bldg., Salt Lake City, Utah.
FORBES, D. L. H....................................Hotel Jardin, El Oro, Mex., Mexico.
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FRICKE, JOHN H., Mining..Bisbee, Ariz.
GERHAUSER, WILLIAM, Secty., Superior Charcoal Iron Co.,
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GRAHAM, KENNETH M., Bentong-Pahang, Federated Malay States,
Straits Settlements.
GRAVE, ERNEST...668 Morelos, Guadalajara, Mexico.
GRAVES, MACDOWELL............................Care Traub Bros. & Co., Detroit, Mich.
GREENE, LEWIS H.. .2612 Haste St., Berkeley, Cal.
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GRISWOLD, WILLIAM T........................ ....341 Sixth Ave., Pittsburg, Pa.
**Gummere, William*, Chem....................................... .....Roebling, N. J. '08.
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**Haley, D. F.*, Min. Engr......................West Gore, Nova Scotia, Canada. '08.
HALL, GEORGE............ ....."Steephill," Boxwell Road, Berkhamsted, England.
HARGRAVES, ERNEST..........Care Colonial Bank, Daylesford, Victoria, Australia.
HARMS, ERNEST...............Cia Metallurgica de Torreon, Torreon, Coah., Mexico.
HARRINGTON, GEORGE B.........2 Chestnut Ave., Chestnut Hill, Philadelphia, Pa.
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HARTRANFT, S. S., Met............ ....Norristown, Pa.
HAUCK, WILLIAM M., Min. Engr., Surveying and Mining,
Vernon, Humboldt Co., Nev.
HAVARD, FRANCIS T..........,.........Care U. S. Metals Refining Co., Grasselli, Ind.
**Hawkins, Tancred*, Mine Mgr., Cappagh House, Ballydehob,
County Cork, Ireland. '08.
HEBERLEIN, CARL A..............................Callejov Sautera 6, Zacatecas, Mexico.
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**Holden, Roy J.*, Teacher..Blacksburg, Va. '08.
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HOOKER, BRIAN, Care W. H. Walker, A. M. P. Bldgs.,
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**Hore, Reginald E.*, Instructor in Petrography, University of Michigan,
Ann Arbor, Mich. '08.
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**Jackson, Clements F. V.*, Chief Inspector of Mines, Dept. of Mines,
Brisbane, Queensland, Australia. '07.
JESSUP, ALBERT B........................302 Coal Exchange Bldg., Wilkes-Barre, Pa.
JOHNSTON, FRED L........ ....325 E. Anapamu St., Santa Barbara, Cal.
JONES, CHARLES COLCOCK.........................308 Henne Bldg., Los Angeles, Cal.
JONES, CHARLES H., Caucasas Copper Co., Care T. B. Scott,
Mattievich & Co., Batoum, So. Russia.
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**Kenney, Eduard F.*, Met. Engr ....,......Cambria Steel Co., Johnstown, Pa. '08.
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**Kong, Shun Tet*, Min. Engr..............116 Vineyard St., Honolulu, Hawaii. '08
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LAUDER, GEORGE.................................Care Home Trust Co., Hoboken, N. J.
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MASON, J. GORDON...................... ....West Pittston, Pa.
MILLER, CHARLES W............................Denver Athletic Club, Denver, Colo.
MILLER, EMORY T ....Monte Cristo Mines, Groom Creek, Ariz.
MILLS, FRANK P..Charleston, W. Va.
MILLS, LOUIS D...Hotel Regent, San Francisco, Cal.
MOORE, REDICK R., Garfield Plant, American Smelting & Refining Co., Salt Lake City, Utah.
MOORE, ROBERT McI., Mech. Engr., Genl. Mgr., Lobbs Hole Central Copper Mining Co., via Tumut, N. S. W., Australia.
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RICHARDS, H. DE C....................................Cosmos Club, San Francisco, Cal.
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SANDOVAL, PROSPERO........Banker, P. Sandoval & Co., Nogales, Sonora, Mexico.
SAWYER, ARTHUR H.........Supt., Keweenaw Copper Co., Delaware Mine, Mich.
SCHOLZ, CARL..205 Old Colony Bldg, Chicago, Ill.
SCHRADER, ERICH J., San Miguel Gold Mining Co.,
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SCHRAUBSTADTER, R. T... ....St. Louis, Mo.
SEAL, ALBERT E..............Normanton-on-the-Wolds, Plumtree, Notts, England.
**Segsworth, Walter E.*, Min. Engr..................103 Bay St., Toronto, Canada. '08.
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SEVIER, JOHN C...P. O. Box 36, Midas, Nev.
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**Smart, Robert*, Territorial Assayer......White Horse, Yukon Territory, Can. '07
STARR, CHARLES C....................................General Delivery, Goldfield, Nev.
STEBBINS, ELWYN W..................................819 Mills Bldg., San Francisco, Cal.
STONE, EDGAR D., Vice Prest. and Genl. Mgr., Georgia-Tennessee
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STORROW, SAMUEL...............................1209 Union Trust Bldg., Berkeley, Cal.
STRAUSS, LESTER W...............................Casilla 849, Lima, Peru, So. America.
STROUT, ERNEST A.......Care Witwatersrand Deep, Knights, Transvaal, So. Africa.
STUCKEY, LEONARD C......Dulcinea Mine, Puquios, Atacama, Chile, So. America.
THOMAS, ALBERT E., Care A. E. Thomas & Co., Min. Engrs.,
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TOLL, RENSSELAER H., Cons. Min. Engr., 532 Mining Exchange, Denver, Colo.
TONKIN, JAMES J., Mgr., La Tortilla Lead Smelting Works,
Linares, Provincia de Jaen, Spain.

TRENGOVE, SAMUEL R..Iron King, Ariz.
TURNER, WILLIAM J., Supt., Ingliston Extended Gold Mines, Ltd.,
Meekatharra, Western Australia.
TURRELL, HAROLD....................................Penhalonga, Rhodesia, So. Africa.
VALLAT, BENJAMIN W.....................Colorado Fuel & Iron Co., Pueblo, Colo.
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WALTER, E. W.....................Genl. Mgr., Giroux Cons. Mines, Kimberly, Nev.
WASHINGTON, HENRY S., Care Washington & Lewis, Mining Geologists,
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WATSON, EDWARD, Care Frederick Harle, Solicitor, Chester-Le-Street, England.
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WEPFER, G. W..Nortonia Hotel, Reno, Nev.
WHEELOCK, RAYMOND P..Searchlight, Nev.
WHELER, AUBREY S., Care Cocks, Biddulph & Co., 43 Charing Cross,
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WHITAKER, DE BERNIERE, Genl. Supt., Juragua Iron Co.,
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WILCOX, JOHN F..Tryon, N. C.
WILDE, THOMAS B..Goldfield, Nev.
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WILLIAMS, RALPH B.......................................P. O. Box 349, Globe, Ariz.
WILSON, GORDON.......................................Benallen, Kirkintilloch, Scotland.
WILSON, JOHN BOWIE, Care Stottenhoff & Co.,
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WILTSEE, ERNEST A....................Room 2416, 165 Broadway, New York, N. Y.
YEATMAN, POPE,.......................................165 Broadway, New York, N. Y.
YOKOYAMA, CHOJIRO............Care Kamaishi Kojan, Kamaishi, Rikuchu, Japan.
YOUNG, JOHN W., 2d Vice Prest., Chalmers & Williams, Inc.,
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ZERN, EDWARD N., Supt., H. C. Frick Coke Co. Mines,
Shoaf Mine, R. F. D. No. 7, Smithfield, Pa.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Barnardo, William S. E.,	Surbriton, Surrey, England.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Bell, Stanislaus C. N.,	Brisbane, Queensland, Australia.
Bellam, Henry L.,	Reno, Nev.
Berry, J. P.,	East Rand, Transvaal, So. Africa.
Bradley, Richard J. H.,	15 William St., New York, N. Y.
Bruce, Thomas C.,	Johannesburg, Transvaal, So. Africa.
Burhans, Harry H.,	Michigan College of Mines, Houghton, Mich.
Cleland, George A.,	Tonopah, Nev.
Dikeman, J. M.,	Rough and Ready, Cal.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Drury, Walter M.,	Velardena, Dur., Mexico.
Durell, Charles T.,	Cima, Cal.
Edwards, Henry W.,	Silver City, New Mexico.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Fleming, William L.,	Springdale, Wash.
Foster, Floyd J.,	Monterey, Mexico.
Francis, George G.,	177 St. George's Sq., London, W., England.
Grabill, Clarence A.,	Sunnyvale, Cal.
Harrison, Alfred W.,	Silverton, Colo.
Jackson, Byron N.,	Milton, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Jones, Edward H.,	Globe, Ariz.
Lukis, E. duB.,	Ica, Peru, So. America.
Mueller, Henry C.,	General Delivery, San Francisco, Cal.
O'Byrne, Joseph F.,	Dahlonega, Ga.
Palacios, Jose G.,	Monterey, N. L., Mexico.
Pickard, Thomas D.,	Hedley, B. C., Canada.
Poillon, Howard A.,	Snowden, Cal.
Reisinger, Paul,	Great Northern Ry. Co., Minot, N. D.
Reynolds, Llewellyn,	22 Webb St., Hammond, Ind.
Roberts, Fred C.,	Crystal Falls, Mich.
Robertson, Horace B.,	El Oro, Mexico.
Roesler, August,	74 Broadway, New York, N. Y.
Royer, Frank W.,	4003 W. 35th Ave., Denver, Colo.
Seward, John,	131 Washington St., East Orange, N. J.
Sharp, W. Goodenough,	Paramibo, Dutch Guiana, So. America.
Shaw, Clarence L.,	Ely, Nevada.
Thomas, George W.,	Exposed Treasure Mining Co., Mojave, Cal.
Thomas, Hubert S.,	Wellfield, England.
Thomas, James A.,	115 New Montgomery St., San Francisco, Cal.
Vaux, Charles A.,	P. O. Box 80, East Rand, So. Africa.
Watson, Ralph W.,	122 E. S. Temple St., Salt Lake City, Utah.
Wolfe, Burton L.,	Ely, Nev.
Young, Frederick E.,	Howe Sound, via Vancouver, B. C., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during March and April, 1908:

Date of Election.	Name.	Date of Decease.
1897.	**William Beals, Jr.,	——— —, ——.
1890.	*Edward D. Chester,	November —, 1907.
1906.	*William T. Climo,	October 19, 1907.
1900.	*John T. Conner,	March 17, 1908.
1879.	*Pat Doyle,	March 27, 1907.
1896.	*Robert J. Forsythe,	——— —, ——.
1898.	*Oliver S. Garretson,	March 18, 1908.
1884.	*Jawood Lukens,	March 10, 1908.

* Member. ** Life Member.

Biographical Notices, March and April, 1908.

Bi-Monthly Bulletin, No. 21, May, 1908.

THE following paragraphs comprise such information as the Secretary has been able to obtain concerning the members and associates whose deaths have been reported. Further particulars or corrections of errors, and biographical data concerning deceased members or associates not already noticed in this way, are solicited.

Pat Doyle was born in 1849. At the age of fifteen he entered the Civil Engineering College of Madras, India, and left it at seventeen, having achieved special distinction in mathematics, chemistry, and geology. Before he was eighteen years old he was in charge of two of the most important Sub-Divisions in the Madras Presidency, where he had ample opportunities for acquiring a preliminary knowledge of his profession, which was his chief object in joining the Public Works Department. In 1867, his energetic measures saved the island of Seringham from disastrous inundation. At this period he began contributing to the press; and after a varied practical experience he came into public notice again in 1876, with an article in the *Colliery Guardian* on Indian Mines and Mining. In 1877 he became a Fellow of the Statistical Society of London. He was a founder of the Straits Branch of the Royal Asiatic Society and a life member of the parent Society of Great Britain and Ireland, as well as a member of the Independent Asiatic Society of Bengal.

In 1878–9 he was Chief Superintendent of the Public Works of Perak; was active in having the Associate Member Class added to the Institution of Civil Engineers; and became a member of the Society of Engineers of London and of the North of England Institute of Mining and Mechanical Engineers. In 1880 he went to the Southern Colonies and held several appointments in Australia, where he became a member of the Johnsonian Club, Brisbane, and the Queensland Philo-

sophical Society. He afterwards visited Java, and finally traveled in China. In 1883 he returned to India and became District Board Engineer of two districts in the Madras Presidency. After this he was a consulting engineer in Oude for various industrial enterprises. In 1885 he visited the Bengal coal-fields, and was largely instrumental in exploding the "Bahour Joint-Stock Project" for the working of lignite near Pondicherry. In this year he started *The Indian Engineer;* and after retiring from that publication, he published the initial number of *Indian Engineering*, of which publication he was owner and editor to the time of his death, Mar. 27, 1907. He joined this Institute in 1879. He was a member of the Royal Irish Academy, the Institution of Civil Engineers, the Institution of Engineers and Shipbuilders of Scotland, a Fellow of the Royal Society of Edinburgh, and a member of the London Society of Engineers, the North of England Institute of Mining and Mechanical Engineers, the Engineers' Club of Philadelphia, Pa., and many other societies.

Adolph Ekman was born Dec. 8, 1858, at Piteå, Sweden. After graduating from the public school he entered the University of Luleå, the capital city of the læn of Norbotten on the Gulf of Bothnia. Upon leaving the university he served an apprenticeship as a pharmacist in his native town, and was employed in laboratories in Piteå and Luleå. He went to Australia to engage in mining and assaying in the vicinity of Adelaide, but was unfortunate in speculation and lost everything. Resolving to leave Australia, he shipped as an ordinary seaman for Honolulu, and thence to Port Townsend, Wash., where he was honorably discharged, proceeding to Seattle, and afterwards to San Francisco. In 1881 he settled at Oroville, Cal., where he practiced his profession as pharmacist until 1883, when he went again to San Francisco. In 1888 he returned to Oroville, and established a pharmacy and drug-store, in connection with which he maintained an assay office, and became expert in the knowledge of California minerals and ores. In 1894 he was placed in charge of the Department of Mining of the California Section at the Mid-winter Fair in San Francisco, and in 1900 he was appointed by Governor Gage to collect, install, and manage the mining exhibit

from California at the Paris Exposition. He was very prominent as a mineralogist. Mr. Ekman will be remembered as the author of the article on the Mineral Resources of Butte Co. in the Souvenir Edition of the California Miners' Association volume, which was presented in 1899 to the members of this Institute, of whom he became himself one in 1902. He died, Mar. 14, 1907, after several years of suffering bravely borne.

Oliver Stevens Garretson was born July 26, 1843, in Ross county, Ohio, and brought up in Salem, Iowa. He was the grandson of Isaac Garretson, the first patentee in the United States of a machine to make and head nails in one operation. In 1865 he moved to Buffalo, N. Y., and was employed, first as mechanic and afterwards as foreman, by the Townsend Manufacturing Co. In 1866 he formed the firm of Garretson & Clarke, and began the manufacture of hardware specialties. This partnership continued but a short time; and in 1869 Mr. Garretson, together with his brother, established the Buffalo Hardware Co., and later, the Buffalo School Furniture Co., which at the present time is one of the largest manufacturers of school furniture in the United States. In 1896 he retired from this business, retaining, however, his connection with the foundry. In the meantime he had assisted in establishing two very large saw-mills at Austin, Potter county, Pa.

Mr. Garretson became a member of the Institute in 1898, and, at the Buffalo meeting, held in October of that year, contributed to the famous discussion of the Kytchtym medal* one of its most interesting features—namely, the demonstration that iron castings of great delicacy could be made from ordinary Scotch foundry iron, or American pig of similar quality.

During the last ten years of his life, Mr. Garretson was actively engaged in developing a plan for smelting and converting copper-sulphide ore in the same furnace. The idea was regarded as meritorious by leading metallurgical authorities, and the inventor was confident that he could deal successfully with the serious practical difficulties which it involved. Unfortunately, his sudden death at Buffalo, Mar. 8, 1908, put an end to his experiments. His last article on the subject, posthumously published in the *Engineering and Mining Journal*

* *Trans.*, xxviii., 613, 848.

of Apr. 12, 1908, evinces much ability and a thorough acquaintance with the elements of the problem.

Tom Cobb King was born June 11, 1866, at Marion, Ala. His father, Porter King, had been a colonel in the Confederate army. After graduating from Howard College, Ala., he became a student at the Massachusetts Institute of Technology in the class of 1887. His very active professional career comprised service as Superintendent of the Briar Hill Coal & Iron Co., Youngstown, O., Superintendent of the blast-furnaces of the Sharon Steel Co., Sharon, Pa.; and a similar position at Ironaton, Ala. During the later years of his life he was Vice-President and General Manager of the National Metallurgical Co. He was a member of the Institute from 1890 to 1895, and rejoined it by re-election in 1906. He died, Feb. 27, 1908, at East Orange, N. J.

Jawood Lukens was born in 1843 in Lebanon county, Pa. He was the youngest son of Lewis A. Lukens. After finishing his school education in Norristown, Pa., he went to the Polytechnic College at Philadelphia, where he graduated as a civil engineer in 1864. He was for a time engaged with an engineer corps in surveying a route for the Pan Handle railroad in West Virginia and Ohio. Later he was engaged in surveying in the oil-fields of Pennsylvania. In 1867 he entered the employ of the Alan Wood Co., and in 1873 took up part of his father's interest in that company. In 1881 he withdrew from the Alan Wood Co., and started the Longmead Iron Co., which was incorporated afterwards with the Conshohocken Tube Works, of which Mr. Lukens was one of the founders. He joined this Institute in 1884, and at the time of his death, which occurred Mar. 10, 1908, he belonged to the following Philadelphia societies: the Engineers' Club; the Franklin Institute; the Union League; the Art Club, and the Manufacturers' Club.

Harry Lee Shrom was born at Greenville, Pa. in 1871. After receiving a high-school education, he entered Thiel College, Greenville, in 1888, graduated in 1893, and began in 1894 a course at the Case School of Applied Science, Cleveland, Ohio, taking chemistry as the main branch. In 1898 he graduated

with the degree of B.S. At the same time he received the degree of A.M. from Thiel College. Immediately after graduation he went to Kirtland, Ariz., to work in a mine in which his brother was interested. After a few months he received a position as assayer for the Aldred Mines, N. C., from his friend, Dr. F. L. Slocum, with whom he continued to be associated until the time of his death. In October, 1901, when the Miami Mining Co. took up the old Phœnix gold property, near Concord, N. C., he became its manager. Early in 1905 Mr. Shrom accompanied Dr. Slocum to Mexico, in the capacity of mining engineer. His work in Mexico, which included the personal examination of every mine in the Parral district, and a general examination of the Inde and Guanenacevi districts, was highly efficient. He was looked upon as one of the "coming men" in Mexico; and his untimely death, caused by falling down a shaft at the Palmetto mine, June 12, 1907, is a great loss to his profession. He joined the Institute in 1901.

MEETINGS AND EXCURSIONS OF OTHER SOCIETIES.

The American Society of Mechanical Engineers.—The semi-annual meeting of the American Society of Mechanical Engineers will be held in Detroit, Mich., June 23–26. A session will be devoted to hoisting- and conveying-machinery; and many other subjects will be treated in professional papers, among which are Clutches (with special reference to automobile clutches); The Thermal Properties of Superheated Steam; The Horse-Power, Friction-Losses, and Efficiency of Gas- and Oil-Engines; A Journal-Friction Measuring-Machine; A Simple Method of Checking Conical Pistons for Stress, and The By-Product Coke-Oven.

The usual receptions will be held and excursions will be made to manufacturing plants, the ship-building yards, and various points of interest in and around Detroit. Among the excursions planned is one to the University of Michigan at Ann Arbor. The Gas-Power Section of the Society will hold a session, and the Society for the Promotion of Engineering Education and the Society of Automobile Engineers will hold meet-

ings in Detroit at the same time. As far as possible, sessions will be arranged so that members interested in subjects treated by the other Societies may attend their sessions without missing papers on related subjects read before their own Society.

Excursion of the Canadian Mining Institute.—This excursion will start from Quebec on or about August 24, and will visit all the important regions of the Dominion except the Yukon Territory. It will be divided into three stages, in any or all of which members and guests may participate—namely: (1) Trip through Quebec and Nova Scotia, including the asbestos and copper regions, coal-mines, and iron- and steel-works, and occupying about 9 days; (2) Ontario excursion, including Montreal and Toronto, Niagara Falls, Sudbury, Cobalt, etc., and occupying 6 days; and (3) Trip to Victoria, including Fernie and Bankhead coal-mines, Moyie silver-lead mines, mines of Rossland and Boundary, Bennington Falls power-plant, etc., and occupying 25 days. The Iron and Steel Institute, the Institution of Mining and Metallurgy, the (English) Institute of Mining Engineers, and other important British and European mining and engineering societies will participate in this excursion. Correspondence concerning it should be addressed to Mr. H. Mortimer Lamb, Secretary, 413 Dorchester St., West, Montreal, Can.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Present Mining-Conditions on the Rand.

BY THOMAS H. LEGGETT, NEW YORK, N. Y.

(New York Meeting, February, 1908.)

IN speaking of the mining and economic conditions prevailing at the present time on the Rand, it is not my intention to go into the details of the mining-practice, since this has been already well described both in the *Transactions* [1] and elsewhere,[2] but rather to take a more comprehensive view of the industry and its surroundings as a whole, marking its general development and the lines of its future progress.

In a paper entitled Deep-Level Shafts on the Witwatersrand, with Remarks on a Method of Working the Greatest Number of Deep-Level Mines with the Fewest Possible Shafts,[3] presented to this Institute in August, 1900, I drew attention to the great cost of sinking the very deep vertical shafts that were then being seriously proposed as necessary for the development of the deeper areas, pointing out the strong advisability of working this ground by means of inclines to be sunk from the existing shafts of from 3,000 to 4,000 ft. in vertical depth.

In this paper it is stated (p. 975):

> "In short, practice upon the Rand now tends towards fewer vertical shafts and more underground inclines, especially for the very deep mining about to be undertaken."

In consequence, the 6,000-ft. vertical shafts, at one time so much discussed, have never been started, and they do not now seem likely ever to be.

The necessity of placing all deep shafts further apart in order to make them control and exhaust larger areas was also dwelt upon. This economy was vitally necessary for both

[1] Gold-Mining in the Transvaal, South Africa, John Hays Hammond, xxxi., 817 to 855 (1901).

[2] *Engineering and Mining Journal*, vol. lxxxv., p. 53 (1908).

[3] *Trans.*, xxx., 947 to 987 (1900).

financial and technical reasons, very few of the deep shafts being operated to anywhere near their full efficiency, and to further this object the advisability of amalgamating many of the deep-level companies was pointed out.

The hard times that the Rand has been going through during the past few years, have emphasized these points very strongly, with the result that the very deep vertical shafts are no longer suggested, while the amalgamation of a large number of the deep-level properties has already been consummated and other amalgamations are under way.

There were many deep-level companies formed 8 or 10 years ago with areas of from 200 to 300 claims (from 280 to 420 acres), which were to be developed by means of vertical shafts placed about 2,000 ft. apart. Many of these properties have been amalgamated, so that the areas are now two or three times the above extent, while wherever possible the distance between shafts has been increased to from 3,000 to 4,000 feet.

In some instances, properties of large area are being opened up by a single deep shaft, which is permissible where connections can be made with adjoining properties, so as to give the two exits required by the Transvaal law.

Under these conditions, several years ago, I started a single 7-compartment shaft to be sunk approximately 4,000 ft. to develop a property of 254 claims (about 356 acres), each of the 6 hoisting-compartments being 5 by 6 ft. inside of timbers, and the pump- and ladder-way 6 by 6.5 ft., and, as stated, several similar single shafts have since been started.

In short, economy in all directions is the order of the day, and necessarily so, since new capital is not easily found for defraying the cost of expensive deep-level development.

An excellent instance of the amalgamation of deep-level properties, already mentioned, is the consolidation of the Knights Central, Ltd., with the South Knights, Ltd., now under way.

The Knights Central has an area of 444 claims (622 acres), a capital of £525,000, and is developed by means of two 5-compartment shafts, about 2,000 ft. apart, and about 2,200 ft. deep each. This company, to-day, has 282,000 tons of ore developed, assaying about 8 dwt., over an average width of reef of 4 ft., which is a highly payable grade of ore, but it has only about £50,000 cash in hand, or not nearly enough to build the

necessary 200-stamp mill and cyanide-plant, and to carry on further mine-development.

The South Knights property has an area of about 450 claims lying on the dip of the Knights Central reef or adjoining that property on the south, where its shallowest depth of reef is about 5,000 ft., and it has a paid-up working-capital of about £300,000 cash in hand. This amount of money is quite inadequate for the necessary shaft-sinking, shaft-equipment and the mine-development, to say nothing of the subsequent milling-plant. In the present strenuous times it would be impossible to raise additional capital, as is evidenced by the fact that not a sod has been turned upon the property, although the company has had nearly $1,500,000 cash in hand since its formation several years ago.

The combining of these two properties gives an area of 894 claims (1,250 acres), insures a very long life to the enterprise, and furnishes the necessary funds for bringing the property to a producing stage, since the cash in hand will then amount to £350,000. It also puts the shareholders of the deeper property within measurable distance (probably 12 or 15 months) of receiving a return upon an investment which has already lain fallow for five years, and which, could they succeed in raising the additional capital necessary to bring it to fruition, would still require 6 or 7 years more.

This example is a fair type of the amalgamations recently accomplished and still going on, chiefly between the mines forming the second row of deep-levels (average depth of reef about 2,600 ft.) and the deeper ground beyond, although in some few instances amalgamations of deep-ground with the nearest outcrop companies are also being discussed.

These combinations are in almost all cases advisable from both technical and financial standpoints. The technical reasons were always more or less apparent, the financial ones not so much so until later years.

Financial Conditions.—It is pertinent to touch upon the financial aspects of these consolidations, not only because the mining business, like all others, is governed by them, but also because one of the leading mining journals of the United States has published the statement that the mines of the Witwatersrand were greatly overcapitalized. I believe it is

demonstrable that the majority of these companies are not overcapitalized.

In the consolidation of the two properties above mentioned, the Knights Central issued £375,000 fully paid £1 shares in payment to the South Knights for its entirely undeveloped property and its £300,000 in cash. The South Knights has a capital of £650,000 (in £1 shares), of which but £500,000 are issued, including 150,000 shares working-capital guaranteed at 35s., this latter feature being the cause of the present large amount of cash in hand.

It is evident that the deeper property suffers a large shrinkage of valuation by this consolidation; it is almost invariably the case that the company owning the deeper and generally largely undeveloped property has thus to suffer in these amalgamations.

With respect to this very deep level ground, the engineer earliest on these fields, Mr. Hennen Jennings, was always very cautious, while Mr. John Hays Hammond uttered a note of warning in 1901, with which all conservative engineers on the Rand agreed, when he said:[4]

> "The results of the developments in the deep-level areas have been so satisfactory as to engender a certain recklessness on the part of mining companies owning very deep reefs. The exploitation of certain of these areas is not regarded by conservative engineers as at present justified, in view of the large intervening tracts of undetermined value which separate mines in operation from the site of proposed mining upon these very deep-level areas."

The redeeming feature of the formation of companies on these deeper areas was the invariable provision of a good round sum for a working-capital, as in the case of the South Knights, and such was the faith of the issuing house in the value of these properties that this working-capital was guaranteed at prices usually much above par.

The result has been, however, that by far the major part of this working-capital has had to be paid by the guarantors (not a pleasant position when the same shares can be bought to-day for one-fourth to one-sixth of the guaranteed price), and this liability can never be avoided, not even by the liquidation of the company.

[4] Gold-Mining in the Transvaal, South Africa, *Trans.*, xxxi., p. 852 (1901).

It speaks well for the character of the financing upon the Rand that none of these deep-levels was floated without this provision of immediate working-capital and in large sums. The consequence is that the deeper companies are in the position to make much better terms when combining with their northern neighbors than otherwise would be the case, while to this amalgamation many of them must inevitably come for the reasons already given.

With reference to the alleged overcapitalization of the Witwatersrand companies, a record of the dividends paid by 47 of them (all the data that is now readily available) for the year 1907 shows an average of 44 per cent. on the aggregate capital, while certain properties did much better, as, for instance, the Crown Reef, 210, and the Ferreira, 300 per cent. The Rand Mines, Ltd., comprising a group of nine producing deep-level mines, paid 130 per cent. in dividends in 1907, and promises to increase this rate during 1908. According to Mr. Ross Browne, the total expenditure in shafts, development, plant and equipment by these nine companies, before reaching the producing-stage, averaged £620,000 per company; consequently, a very considerable capitalization is warranted.

The report of the Mines Department of the Transvaal for November, 1907, shows 71 mines "dropping stamps" on the Rand; hence, it is evident from the foregoing that the majority of these mining companies are far from being overcapitalized.

It is undoubtedly true that the stock market has overcapitalized these companies several times, and probably this fact has led to a confusion of ideas on this subject. Doubtless some of the deep-level mines, more especially the developing ones, to-day seem to be overcapitalized, but they did not so appear at the time of their flotation, else the working-capital would never have been so cheerfully guaranteed at a high premium. Moreover, it is far from certain that they will be so regarded a few years from now, when further development and improved economic conditions bring their welcome changes.

About five years ago I examined a developing deep-level mine that showed only 40 per cent. of 500,000 tons of ore in sight to be payable. To-day this property is making profits of £60,000 per annum and steadily improving, while it is unques-

tionably crushing much of the ore that five years ago was unpayable.

Working-Costs.—As a mining-camp grows older the working-costs almost invariably decrease, providing the camp maintains a healthful activity with advancing years, and this has been the case on the Witwatersrand, the result being as follows:

1898, average working-costs of 65 companies, . . .	25s. 1.3d.
1899, average working-costs of 42[a] companies, . .	25s. 2.7d.
1906, average working-costs of 58 companies, . . .	22s. 1.0d.
1907, average working-costs of 56[b] companies, . .	20s. 8.0d.

[a] The Boer war broke out in October, hence the records are incomplete.

[b] Two less than in 1906, due to exhaustion of the Bonanza mine and incomplete records from one other mine.

These costs include mining, development, crushing and sorting, milling, cyaniding, maintenance and general expenses, but they do not cover depreciation and amortization, these items being more properly dealt with by the Directors at the end of the year. These results show the very material decrease of 4s. 6d. per ton since 1899, and are therefore approaching now to the 6s. reduction predicted by Mr. John Hays Hammond in 1901, but it has taken time to attain this result, as I then pointed out it would do. A comparison of the costs in 1907 with those of 1906 shows a decrease of 1s. 5d., or 34 cents, per ton, due chiefly to decreased wages and increased efficiency of both white and colored labor, including the Chinese in the latter category, though increased crushing-capacity through the use of heavier stamps (up to 1,670 lb. per stamp) and regrinding in tube-mills have also aided.

In 1906, 58 companies mined and milled 13,065,624 tons of ore at a total cost of £14,411,219, while in 1907, 56 companies mined and milled 14,861,234 tons at a total cost of £15,351,749, being an increase of 1,795,610 tons for an increased cost of only £940,530.

Most of these economies were attained during the latter half of 1907, after the white-miners' strike, and some mines made startling reductions, as, for instance, the Robinson, which reported costs of 14s. 9d. for November, and the Glencairn, of 15s. 1d. per ton.

Such strenuous and successful efforts are now being made to

reduce still more the working-costs on the Rand, that I think it safe to anticipate another large decrease for the year 1908.

Output and Dividends.—The total output of the Witwatersrand district for 1907 was 6,220,227 oz. (213.27 tons) of fine gold, equal to an average of 17.75 tons of gold per month. The present yield exceeds 19 tons of gold per month. The value of the output is approximately £26,436,000 ($128,572,000), an average of $10,714,300 per month for the year. This amount does not include the "outside" districts of the Transvaal, which are producing in addition about 20,000 oz. of gold per month.

The returns available to date from 56 companies show a total yield during 1907 of £25,154,591, which is equal to 33s. 10.2d. per ton, and a total profit of £9,805,906, equal to 13s. 2.3d. per ton.

The yield per ton for the entire district is practically 34s., or $8.25, which is about 6s., or about $1.50, less than the average return of 10 years ago. On the other hand, working-costs have been reduced 4s. 6d., and are still decreasing, while nearly three times the amount of ore is being crushed as in 1897, although the number of producing companies has not been increased 25 per cent. The number of stamps, however, has been more than doubled, 3,567 stamps in 1897 and 8,375 stamps in November, 1907. Small companies have dropped out and larger ones, both outcrop and deep-level, have taken their places, while many outcrop companies have greatly increased their crushing-capacity.

The dividends for 1907, declared up to January 1, 1908, amount to £6,937,187, or £1,202,026 in excess of the dividends for 1906, and these amounts are exclusive of the 10 per cent. profit-tax, from which the Transvaal government should derive an income for 1907 of about £760,000. These dividends represent slightly more than 25 per cent. of the gross output of gold from this district for the past year, certainly an excellent record for any mining-district.

Hatch and Leggett in the paper, An Estimate of the Gold Production and Life of the Main Reef Series, Witwatersrand, down to 6,000 Feet,[5] predicted an ultimate annual yield of

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[5] *Transactions of the Institution of Mining and Metallurgy*, vol. xii., p. 44 (1902–3).

£30,000,000. The yield is now within 12 per cent. of that estimate, which it bids fair soon to reach.

The output for the entire Transvaal for 1907 was £27,403,738, an increase of £2,823,741 as compared with 1906; practically all this increase was due to the Rand proper.

Labor.—The papers by Mr. T. Lane Carter presented to the Institute at this meeting give a full description of the Kaffir- and Chinese-labor conditions on the Rand. There is one important point, however, that does not seem to be generally understood—namely, that the introduction of the Chinese into the Transvaal is not on a par with their introduction into Canada, Australia, the United States or any of the countries that object to their presence. In these latter countries the Chinaman comes immediately into competition with white labor, while in the Transvaal he does not, because there already exist there two planes of labor, the white and the black, and the Chinaman has been rigorously confined to the latter.

In any country where white and black labor work side by side, there are always certain things the white laborer considers *infra dig*, and he will always relegate these to the black. The white man is always scrupulously careful to keep the black on the lower level, and to not allow him to rise, since that would mean competition. In the Transvaal the white miner has the overseer's position and the black man does most of the hard work. Engine-drivers and mechanics are white men; in fact, skilled work of all kinds has always been done by the white man, and always will be done by him.

The Chinese have simply supplemented the supply of Kaffirs, and have never been in competition with the white labor any more than are the 100,000 or more Kaffirs now at work in the mines in such competition. Nobody has ever objected to these Kaffirs working with, and under the direction of, the white miners, and as there are 6,000,000 of them south of the Zambesi alone, the country can never be made a "white man's country" in the full sense of that term.

It is evident that the feeling against the Chinese, founded as it is upon a valid and practical cause in other countries, has no such basis in the Transvaal, and is there but an empty sentiment; one, however, that was worked to such an extent in England, where the average man knew nothing of the real con-

ditions and supposed the Chinese would eventually oust the Briton, that the former have to be sent home on the expiration of their contracts. This has been going on for some time, so that out of the 53,000 Chinese in the country at the end of 1906, it is estimated that but comparatively few will remain by the end of this year.

The repatriation of the Chinese is a loss to the mining-industry of the Rand, since they are more intelligent than the Kaffirs and have become very adept at mining-work. Moreover, they are on a 3-year contract, while the Kaffirs seldom stay for more than 6 months at a time, though they often return

The question now is, can all the Chinese be promptly replaced by Kaffirs, to whose scarcity after the war the introduction of the coolie is due. On this point divers opinions have been expressed, but thus far they have been so replaced, in the month of November, 1907, no less than 4,610 Chinese having been sent away and their places filled by Kaffirs. The Transvaal government, acknowledging its responsibility for sending away the Chinese, has put itself on record as desirous of aiding the mining-industry in every way in its power to secure Kaffirs, and as they have perhaps more ways of doing this, it seems highly probable they will succeed.

As to white labor, the miners' wages, heretofore excessive, have been reduced, partly due to the necessity of giving work to the hundreds of unemployed in and around Johannesburg, with a resultant benefit to all concerned, since the efficiency of this class of labor has been much improved.

Before the strike the white miners' pay was £1 per fathom stoped, based on the work of the poorest miner, with the result that capable contractors made enormous profits; to-day contract prices are reduced, and, what is still more essential, are based upon the capacity of the best miners.

Annual and Quarterly Reports.—The mining-companies on the Witwatersrand publish such full and complete reports of their operations, that they can well serve as a model in this respect to the rest of the world.

They comprise reports of the board of directors, the consulting engineer and the manager, and give very full and complete tables, showing the technical details, costs, and results of the operations, together with full financial particulars, comprising

usually a balance-sheet, revenue and expenditure, or profit and loss account, and an appropriation account; but above all they show the tonnage in sight at the end of the year and its value, and describe the mine-development and the appearance of the bottom levels of the mine.

The quarterly reports issued regularly to the shareholders give in the same way the results of the preceding three months' work, yield, costs and profit, together with a short description of the appearance of the mine, latest developments, tonnage of ore in sight, and oftentimes its value.

Many mining-companies in London now send monthly postal cards to each stockholder giving the amount of ore treated, the yield, cost and profit for the preceding month, and any important feature of the month's development on the mine.

In this day of reform in corporate management it is to be hoped that many of the American mines, well managed in all other respects, will copy the methods and practice of the English companies.

Outlook.—With regard to the outlook for the mining-industry, it is several years since I was in Johannesburg, and it is therefore appropriate to quote the views of those who have more recently visited these gold-fields.

Mr. W. Fischer Wilkinson says:[6]

> "There is still a considerable margin between the average working costs and the average recovery [*average recovery* $8.25, *average costs* $5 *per ton*—T. H. L.], and a still further lowering of the grade may be expected, carrying with it a corresponding increase in the tonnage available for profitable mining. Low-grade ores of a value of 5 dwt. per ton or so, which were formerly considered worthless or of little value, are now becoming a valuable asset, and the prospective lives of the working mines are constantly having to be lengthened to meet the altered conditions. Undeveloped properties or those partially developed, whose prospects with costs at 30s. per ton or thereabouts were not bright, can look forward to a profitable existence now that costs have been in many cases reduced to 20s. or less. The possibility of working low-grade ores profitably has now been amply demonstrated, and there is no danger of the Transvaal's failing to contribute heavily to the world's supply of gold for many years after the exhaustion of the richer mines of the Central Rand."

Evidence given before the Mining Commission in Johannesburg during 1907 was to the effect that 39 of the dividend-paying companies had an average life of 12 years and 8 months. Since the life of every mine exhausted to date has

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[6] *Engineering and Mining Journal*, vol. lxxxv., p. 53 (1908).

been greatly underestimated, sometimes by as much as 50 per cent., and since much lower grade ore will eventually be worked than is at present milled, it is safe to say that the average life of the above 39 properties will be at least 15 to 16 years. It would be interesting to have the estimated average life of a greater number of the properties; but as there were 71 mines that dropped stamps in November, 1907, of which about 50 are paying dividends, and as more deep-level mines will soon join the ranks of the producers, it seems reasonable to expect not only a maintenance of the present output for some years, but even an increase up to £30,000,000 per annum for a part of that time.

As regards development in the deep-level mines, upon which so much depends, although high-grade ore, assaying in the ounces, was struck in the Cinderella Deep at a vertical depth of 4,000 ft., and while the Knights Central (still developing) has large quantities of 8-dwt. ore at a vertical depth of about 2,400 ft., I am informed that other mines show long stretches of 5- and 4-dwt. ore, with only occasional higher-grade reef.

It is therefore imperative that working-costs should be reduced still further, in the near future, before these deep-level mines reach the producing stage; and in this connection it is interesting to note that Mr. Ross Browne, who has recently made a 2-year study of the conditions on the Rand, states, as his opinion, that if the white and the Kaffir labor were made more efficient, which he believes can be done, and the cost of supplies lessened, working-costs could then be reduced to 15s. per ton.

This is a most encouraging statement, coming as it does from a specialist in the subject, and made at a time when the working-costs were 22s. per ton.

There is no doubt that costs will be reduced below 20s. during the present year, probably to 19s., perhaps even better than this, for higher efficiency of both white and black labor is now the earnest objective of all the mine-managements, and when one reflects that these two items comprise about 62 per cent. of the total working-costs it is evident what an effect upon these costs the greater efficiency of labor will have. It is also to be noted that as the efficiency of the miner increases, the

cost of supplies decreases; he consumes less or makes a given quantity go further.

Improvements in the metallurgical practice have brought the extraction up until it is now about 95 per cent. of the assay-value of the ore, an important matter when one considers that the saving of one grain of gold per ton of ore crushed means, at the present scale of operations on the Rand, an increased yield of $600,000 per annum. Finally, Mr. Wilkinson considers 5-dwt. ore to be now a valuable asset in any Rand mine—all of which goes to show how time is working in favor of all the mines on the Rand, and especially the deep levels.

In more than one deep-level mine the stopes have turned out better than the assay-plans have indicated, and when one reflects that the drives are now from 200 to 300 ft. apart (even 400 ft. in some deep-level mines), and the connecting winzes separated by distances of 400 ft. and more, it is evident how this may happen. Again, later development has shown that poor zones occur in more or less horizontal stretches, so that the bottom levels of a mine may all be in poor ore at the same time, but on pushing down through this zone the development has again disclosed the normal grade of reef.

Hence, it is now thoroughly well recognized on the Rand that deep-level mines must have from 5 to 10 miles of intelligently directed development-work on the reefs themselves before a valid opinion can be formed of the value.

To summarize, we find that the Witwatersrand output has increased about £2,800,000 in 1907 as compared with 1906, while the dividends have increased £1,200,000, and working-costs have decreased 1s. 5d. for the same period, with another heavy reduction practically assured during the present year.

The use of tube-mills and of heavier stamps has increased the stamp-duty about 1 ton, until it is now 5.8 tons per stamp, while the extraction has been increased to about 95 per cent.; hence, tailings that a few years ago ran about 1 dwt., or $1 per ton, now assay but half that amount, with the result that lower-grade ore can now be worked than ever before; in fact, one mine is actually in operation at present on a yield of only $4.31 per ton, or, say, 4.5-dwt. ore.

The possibility of a shortage of Kaffir labor by next July or

August is to be considered, but this may easily prove to be not as serious as some now consider it.

The Rand has been going through very depressing times, the natural reaction from over-speculation, with the result that everything is viewed there to-day "as through a glass, darkly."

But the hard times have had a very salutary effect; efforts are being concentrated along the proper lines to secure economy in all branches of its great gold-mining industry, and the results of these are bound to tell favorably in the near future.

DISCUSSION.

ALFRED JAMES,* London, Eng.:—I thank you, gentlemen, for your kind invitation to address you. It is a very great pleasure for me to be here at your annual meeting, and, although I have been a member since 1894, this is the first opportunity I have had to attend a meeting of the Institute. Perhaps it is all the more a fortunate coincidence that I am here now, because it so happens this year that you have as your President a very distinguished mining engineer, who is representative of the body of engineers who have done so much for the Rand; and, besides, you have been fortunate in having presented a paper from Mr. Leggett, one of those very engineers to whom South Africa is so much indebted.

Twenty years ago mining was not the sound commercial undertaking that it has since become; but now, with high-grade engineers leaving as little as possible to chance, the stage to which Mr. Leggett refers has been attained. And here I want you to notice particularly that the Rand is now producing 25 per cent. more than the world's total output of gold when the American engineer first went there. The value of the total output of gold in the world during 1888 was $110,196,915, while the value of the output of the Rand alone for 1907 was about $128,750,000, which shows the progress that has been made.

With regard to some of the points to which Mr. Leggett has specifically referred, I was in South Africa in January of this year, and I was surprised to find the cheerful feeling concerning labor, in spite of having to return the Chinese laborer

* President of the Institution of Mining and Metallurgy.

home. This optimism was remarkable, because a native is engaged for six months only, and then he goes away, while a Chinaman is held for three years and trained to become a highly proficient worker. Contrary to the general expectation, however, it was found at the end of December that quite a large body of natives was ready and willing to work, and, as Mr. Leggett pointed out, it was a strange sight to witness these natives begging for work instead of having them brought in under contract by contractors, as was formerly the case. There were, of course, various reasons for this new condition; one is, that during the war there was a big demand for natives and they got very well paid, but they have been living on that money since the war and have spent it, and now they are seeking work. Immediately after the war there was a dearth of native labor, but now the natives are coming back to earn more money.

With regard to the future production of the Rand, it may not continue to increase as rapidly as it has in the past. If you will review the technical literature of the world you will find that it was seriously stated that it paid best to work out everything in the quickest time possible, because of the saving of interest on capital from the more rapid distribution of profits, as well as from lessened costs arising from working on a larger scale. This reasoning, if carried out to its logical conclusion, would show that it would pay best to work out the whole earth in ten years. I think the Boer government is not going to favor this view. The order of the day is to husband all the money that has been subscribed, and to have it used most profitably. I think the government will desire to keep the mines going at a reasonable and decent rate for many years to come, so that, in the meantime, the other industries of the country will have a chance to develop.

I was surprised on my recent visit there to find that so many men were running farms successfully in the Cape Town districts. There has been a collapse in trade, but the agricultural districts are doing well. If, by means of the gold-industry, aid is given to the permanent interests of the Colony, it is really good business, from a political point of view, not to have the gold produced too soon.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Charcoal and Coke as Blast-Furnace Fuels.

BY R. H. SWEETSER, COLUMBUS, OHIO.

(New York Meeting, February, 1906.)

THERE are so many conditions affecting blast-furnace results that it is hard to get satisfactory comparative data on the working of two furnaces, and much more difficult to get comparable results from the use of two entirely different fuels. The several advantages of charcoal over coke as a blast-furnace fuel have doubtless been apparent to many managers; but probably the conditions for comparative tests of the two were never so favorable as during the year 1905, at the works of the Algoma Steel Co., Sault Ste. Marie, Ontario, which comprise two modern blast-furnaces, well equipped, though of comparatively small capacity. For four consecutive months one of these furnaces was run with charcoal and the other with coke. Then the charcoal-furnace ran for a while with part charcoal and part coke; and, still later, with coke only. The ore-mixtures were about the same in the two furnaces, and, of course, all the climatic conditions were identical.

The dimensions of the two furnaces, and their work with the different fuels, are given in Table I.

TABLE I.—*Dimensions and Working of Furnaces at Sault Ste. Marie.*

	Furnace No. 1.		Furnace No. 2.
Height,	70 ft. 0 in.		80 ft. 0 in.
Bosh diameter,	13 ft. 6 in.		15 ft. 6 in.
Hearth,	8 ft. 6 in.		10 ft. 0 in.
Stock-line,	9 ft. 6 in.		10 ft. 6 in.
Bell,	6 ft. 0 in.		7 ft. 0 in.
Cubic contents,	6,119 cu. ft.		8,913 cu. ft.
Number of tuyeres,	9		9
Diam. of tuyeres,	5 in.		5 in.
	Charcoal.	Coke.	Coke.
Maximum day's product,	173 tons.	237 tons.[a]	339 tons.
Maximum week's product,	1,004 tons.	1,453 tons.	2,175 tons.
Maximum month's product,	4,071 tons.	6,131 tons.[b]	8,027 tons.
Date blown in,	Mar. 6, 1905.	July 16, 1905.[c]	Oct. 17, 1904.

[a] Feb. 4, 1906. [b] March, 1906. [c] Changed from charcoal and coke to all coke.

Two important facts were demonstrated during the four months' run of No. 1 with charcoal: (1) that a modern blast-furnace of approved form and construction, equipped with up-to-date machinery, and 70 feet high, could be successfully operated with charcoal as fuel; (2) that, with few exceptions, the equipment and the blast-furnace practice best suited to successful coke-furnaces were also well adapted for the charcoal-furnace.

Tables II. and III. give the averages of the results obtained during the three months of the period under consideration. No allowances have been made for lost time, although furnace No. 2 was shut down for several days in April to put on a new tuyere-jacket.

TABLE II.—*Data of Results of Furnace Operations.*

Furnace No. 1, Charcoal.

1905.	Theoretical Yield. Per Cent.	Actual Yield. Per Cent.	Loss in Yield. Per Cent.	Mesabi Ore. Per Cent.	Cu. ft. Blast per Ton Pig.	Fuel. Lb. per Ton	Quantity of Stone per Ton of Pig. Lb.	Product for Month. Tons.	Average Quantity per 24 Hrs. Tons.	Quantity of Blast per lb. of Fuel. Cu. ft.
April	57.20	56.40	0.80	33.4	91,421	2,120	393	3,722	124.1	43.11
May	58.51	58.30	0.21	33.7	83,899	2,016	308	4,040	130.3	41.60
June	57.73	55.60	2.13	34.0	99,495	2,114	403	3,732	118.9	46.94
Average	57.81	56.76	1.05	33.7	91,605	2,083	368	3,831	124.4	43.88

91,605 cu. ft. of air = 7,338.4 lb. = 3.27 tons of air per ton of pig (charcoal).

Furnace No. 2, Coke.

1905.	Theoretical Yield. Per Cent.	Actual Yield. Per Cent.	Loss in Yield. Per Cent.	Mesabi Ore. Per Cent.	Cu. ft. Blast per Ton Pig.	Fuel. Lb. per Ton	Quantity of Stone per Ton of Pig. Lb.	Product for Month. Tons.	Average Quantity per 24 Hrs. Tons.	Quantity of Blast per lb. of Fuel. Cu. ft.
April	57.30	54.70	2.60	23.5	134,739	2,171	1,036	5,267	205.3	60.17
May	58.79	57.80	0.99	26 9	140,307	2,107	1,037	7,148	230.6	66.52
June	58.16	55.00	3.16	28.3	148,103	2,343	1,050	6,670	227.8	63.20
Average	58.08	55.83	2.25	26.2	141,049	2,207	1,041	6,361	221.2	63.29

141,049 cu. ft. air = 11,283.9 lb. = 5.03 tons of air per ton of pig (coke).

TABLE III.—*Analyses of Pig-Iron and Slag.*

Furnace No. 1.

1905.	Analysis of Pig Iron.				Analysis of Slag.							
	Si. Per Cent.	S. Per Cent.	P. Per Cent.	Mn. Per Cent.	SiO_2. Per Cent.	Al_2O_3. Per Cent.	$SiO_2+Al_2O_3$ total. Per Cent.	Fe. Per Cent.	Mn. Per Cent.	CaO. Per Cent.	MgO. Per Cent.	S. Per Cent.
April	1.22	0.010	0.086	0.52	42.15	11.02	53.17	0.74	0.62	43.00	1.25	0.24
May	1.63	0.014	0.083	0.61	44.49	12.02	56.51	0.87	......	....	......	......
June	1.53	0.010	0.082	0.51	45.76	9.99	55.75	1.29	......	....	......	......
Average	1.46	0.011	0.0836	0.546	44.13	11.01	55.14	0.966	0.62	43.00	1.25	0.24

Furnace No. 2.

1905.	Si. Per Cent.	S. Per Cent.	P. Per Cent.	Mn. Per Cent.	SiO_2. Per Cent.	Al_2O_3. Per Cent.	$SiO_2+Al_2O_3$ total. Per Cent.	Fe. Per Cent.	Mn. Per Cent.	CaO. Per Cent.	MgO. Per Cent.	S. Per Cent.
April	1.48	0.031	0.074	0.49	37.48	11.84	49.32	0.63	0.34	48.10	1.46	1.32
May	1.39	0.027	0.072	0.53	38.12	11.77	49.89	0.62	......	....	......	......
June	1.50	0.029	0.067	0.54	39.17	10.94	50.11	0.74	......	....	......	......
Average	1.46	0.029	0.071	0.52	38.26	11.51	49.77	0.663	0.84	48.10	1.46	1.32

By comparing these two sets of results, it will be seen that charcoal has the following metallurgical advantages:

1. The furnace consumes considerably less charcoal than coke per ton of pig.

2. Only about one-third as much limestone per ton of pig iron is required in a charcoal-furnace as in a coke-furnace.

3. The requirement of blast by a charcoal-furnace is only about 65 per cent. of that by a coke-furnace of the same productive capacity.

4. The "critical temperature" in a charcoal-furnace may be lower than in a coke-furnace.

These four advantages involve many other smaller ones which affect the cost of equipment and of operating: *i. e.*, less fuel and limestone to handle; less blowing-engine equipment; less steam; less hot-blast stove area for heating the blast; lower blast-pressure on the engines, stoves and connections; less flue-dust carried over by the waste gases, and, consequently, a little higher yield from the same ores; less cooling-protection in the hearth and bosh-walls; and practically entire freedom from any high-sulphur pig-iron.

It was very evident during the three months of the above comparison that the charcoal-furnace could not do itself justice on account of the poor quality and the insufficient supply of the charcoal. But even under these adverse conditions the results of three months' work showed the advantages of the charcoal.

Quantity of Fuel Per Ton of Pig.—In comparing the quantity of fuel required per ton of pig, the results given are based on the net tonnage of pig delivered to the Bessemer Department, and the gross tonnage of coke and charcoal delivered to the furnaces, including waste. On account of the frightfully poor quality of the charcoal this waste, at times, amounted to 16 per cent. The results for the period of three months show a consumption per ton of pig-iron of 2,083 lb. of charcoal, as compared with 2,207 lb. of coke.

The work for a coke-furnace was exceptionally good, while for a charcoal-furnace it was very poor. Every pound of coke less than 2,240 lb. per ton of pig will be an almost unlooked-for gain at the "Soo" unless the yield of the ores is much higher than at present. During 1905 the average quantity of

coke per ton of pig-iron required by the furnaces in the Mahoning and Shenango valleys, exclusive of those of the U. S. Steel Corporation, was 2,311 lb. Including these latter furnaces, making a total of 89 furnaces, it was 2,234 lb.

The quantity of charcoal consumed per ton of pig—viz., 2,083 lb.—was excessive. If the quality had been good, the consumption would have been nearer 1,800 lb. Some furnaces using good charcoal have made iron with 1,600 lb. of charcoal per ton of pig. It is safe to count on a saving of 400 lb. of fuel in favor of charcoal.

On account of the practical absence of mineral matter in the charcoal, there is no fuel consumed to slag the ash, nor is there need of limestone to flux it. Moreover, the entire absence of sulphur in the charcoal makes it possible to have a very acid slag, which is consequently much less refractory than the slag necessary for the same ores using coke as fuel.

Limestone Per Ton of Pig.—A comparison of the analyses given in Table III. shows that much less lime is required in the charcoal-iron slag than in the coke-iron slag. The chief reason for this is that there is scarcely any sulphur to be carried off in the charcoal slag. In addition to this advantage there is also a greater gain by not having to flux the ash. But the practice with charcoal at the "Soo" differed somewhat from that in northern Michigan, where much less limestone is used. At the suggestion of Mr. Wm. Wilkins, of Ashland, Wis., less limestone was tried, but the results were less satisfactory. A slag containing SiO_2, 40.78; Al_2O_3, 13.20; and Fe, 0.35 per cent. was all right, and the furnace worked smoothly on it under a blast-temperature of 1,200° F. A slag with SiO_2, 38.74; Al_2O_3, 12.35; and Fe, 0.20 per cent. was a little "limey," and one with SiO_2, 37.12; Al_2O_3, 11.54; and Fe, 0.25 per cent. was too "limey." A slag with SiO_2, 55.52; Al_2O_3, 9.13; and Fe, 0.90 per cent. worked very badly.

In a charcoal-furnace there is the same chance as in a coke-furnace to have the mixture too "dry." The volume of slag must be sufficient to make the furnace work smoothly, and eliminate troubles arising from a cold, stiff-running slag.

One charcoal-furnace manager wrote me that he used only 175 lb. of limestone per ton of pig-iron, with ores carrying about 6 per cent. of silica.

The small amount of limestone required in a charcoal-furnace gives less weight of material to handle and less bulk in the furnace itself, which reduces the cost of stocking and charging. It also gives less slag to handle, and reduces the cost of switching and of repairs to the cinder-ladle.

Air Per Ton of Pig.—One of the great advantages of the use of charcoal over coke is the smaller quantity of blast required per ton of pig. A pound of coke requires nearly 50 per cent. more air for its combustion than does a pound of charcoal. This great saving allows cheaper blowing-engines, less boiler-capacity and less hot-blast stove capacity; consequently, the lesser cost for installing and operating engines, boilers, stoves, pumps, steam-lines, blast-mains, gas-mains and connections. Moreover, the labor for operating and for repairs is less.

Another advantage of this smaller quantity of blast is the smaller margin of loss, as shown in Table II., by a comparison of the difference between the theoretical and the actual yields. The loss in yield of the charcoal-furnace was only 1.05 as compared with 2.25 per cent. of the coke-furnace. The charcoal-furnace carried 7.5 per cent. more Mesabi ores than the coke-furnace. This smaller quantity of blast naturally carries much less moisture per ton of pig into the furnace.

The great difference in blast-volume for the two fuels was most clearly demonstrated when the change was made from charcoal to coke. No stop or interval was made, the coke being gradually substituted for charcoal, and the engine revolutions increased to meet the demand for more air.

The chart, Fig. 1, shows the average blast-pressure, tons of pig-iron per day, and average number of rev. per min. from June 10 to July 23. During the greater part of this period the furnace was running on charcoal, and the quantity of blast blown (and consequently the amount of pig-iron made) was regulated by the daily supply of charcoal, which was never sufficient to blow the furnace as hard as it should have been blown for most advantageous working. Two abnormal results were brought about by this light blowing: 1, the blast-pressure of from 9 to 10 lb. was higher than it should have been; and 2, the furnace had practically a ring-scaffold, which was gradually worked off later, after coke was used and more blast was blown into the furnace.

During the last week in June, when it was seen that the use of charcoal must be abandoned, a small extra supply was obtained, and the engine revolutions were increased for a while, which gave an increased product, but there was no increase in

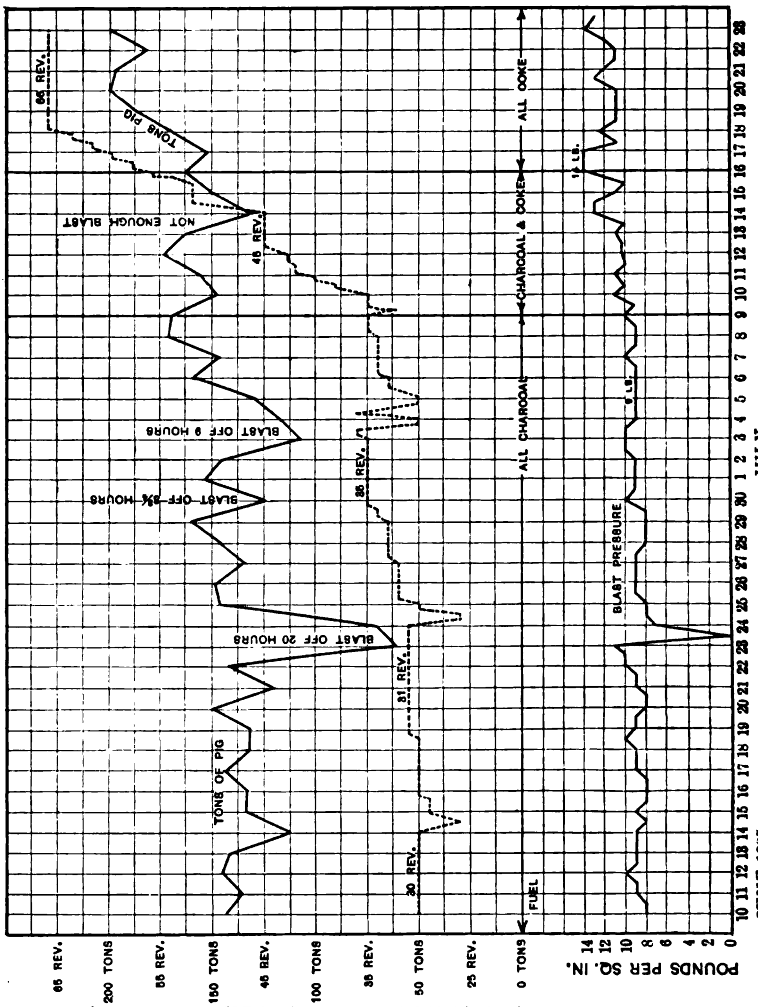


FIG. 1.—DATA OF OPERATIONS OF FURNACE NO. 1, AT SAULT STE. MARIE, ONT.

the blast-pressure. Trouble with the hoist and a shortage of charcoal on July 3 caused a shut-down of 9 hr. But from July 6 to 10, there was enough charcoal to allow blowing at the rate of from 34 to 35 rev. per min. Under these conditions, the consumption of charcoal, per ton of pig, was 1,725 lb., and

the quantity of product arose to 173 tons per day. Then, for a week, a mixture of charcoal and coke was used, the proportion of coke being gradually increased until all the charcoal was replaced, which occurred at the second charge on the day turn of July 16. Although endeavors were made to increase the quantity of blast fast enough to take care of the coke as it came to the tuyeres, it was not fast enough on the 13th and 14th, and consequently the rate of production dropped back. A more rapid increase in volume of blast brought the expected increase in product. During the transition from charcoal to coke, both fuels could be easily seen at the tuyeres mixed together.

The Critical Temperature.—The construction of the furnace was not changed after supplanting charcoal by coke. But the increase in blast-volume and temperature of the hearth soon began to affect the brick-work of the hearth, the tuyere-circle and bosh-walls. Extra bosh-plates were inserted between the tuyere-coolers, and later much trouble arose from thin walls all around and above the tuyeres. Our experience showed that in a coke-furnace stronger walls and more water-cooling devices were necessary than in a charcoal-furnace.

In order to obtain pig-iron having the same percentage of silicon, the hearth of the coke-furnace was hotter than the hearth of the charcoal-furnace, the slag in the former being more refractory than in the latter.

The Product.—The average silicon in the pig-iron made during the three months' run was identical in the two furnaces, but the average sulphur in the charcoal-iron was only 0.011 per cent. as compared with 0.029 per cent. Rarely did the sulphur in the charcoal-iron exceed 0.021 and never more than 0.032 per cent. On account of the higher phosphorus-content of the charcoal, the charcoal-iron contained more phosphorus than the coke-iron from the same ores. The manganese in both kinds of iron was about the same.

Disadvantages of Charcoal.—There are two serious disadvantages in using charcoal instead of coke, although both can be overcome. The first is the difficulty of getting a sufficient supply of good charcoal. The cord-wood needed for making the daily supply of charcoal for a furnace producing 150 tons of iron per day would make a pile half a mile long. The necessary areas of maple and birch forests are becoming less and

less plentiful in the United States, although in Canada there are immense tracts of wooded lands waiting to be cleared for settlers, which contain much of the wood that is better suited for making charcoal than it is for use as lumber.

The second disadvantage is the readiness with which charcoal catches fire, a danger which is not past until the charcoal reaches the tuyeres. Even in the upper part of the furnace, there is a chance of serious trouble from the flaming charcoal if the furnace should make a heavy slip. Furnace No. 1 made many heavy slips on account of dirty charcoal and insufficient blast-pressure, and almost always the fine charcoal-dust would ignite as it was thrown out of the top explosion-doors. At times the flames would reach the ground. But all this could be avoided with a sufficient supply of good charcoal from kilns close to the furnace.

It is interesting to note that during the time furnace No. 1 was running on charcoal and making the largest recorded outputs for charcoal-furnaces, there was also in blast in Canada what are probably the smallest charcoal blast-furnaces in active operation in the world. In Drummondville, Quebec, two small stone-stack charcoal-furnaces of the old French type, built in 1880 and 1881, were operated in the most primitive style and gave a total daily output of 3.5 tons of pig-iron per furnace. The dimensions of one of these furnaces are: 31 ft. high, 10 ft. long and 3 ft. 8 in. wide; and of the other, 32 ft. high, 9 ft. long and 3 ft. 8 in. wide.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Primary Gold in a Colorado Granite.

BY JOHN B. HASTINGS, DENVER, COLO.

(New York Meeting, February, 1908.)

TEN miles from Hartsel, near Antelope springs, in Park county, Colorado, there is a large area of unconsolidated lake beds, which are interesting because at least a part of the lacustrine sands contains in the aggregate an immense amount of gold.

During 1906, one of the arms of this dessicated lake was fairly well prospected with shafts and cuts by an Eastern company to test its value, as favorable amounts of gold had in some instances been found upon it. The claims of the company contain about 5,000 acres of the beds; but this is only a small portion of them, a south branch from a main body, which is at least 7 miles in diameter, with other and very wide lateral gulches, paralleling the one herein described on the east and west. A certain amount of digging and sampling was done in the outside areas; but the result was evidently unsatisfactory, since the work was discontinued.

This section of Colorado has not been studied geologically, and the age of the ancient lake is unknown. It is probably Quaternary. I spent two weeks on the ground, in September and October, 1906, but was quite absorbed in the sampling. I looked, however, for terraces on the rim-rock and other evidences of movement and erosion, but did not find anything to denote an earlier age than the Quaternary. The granite rim-rock may be Archean; S. F. Emmons says that some of the granites in central Colorado are as old as that.

The rim-rock as observed is a gray quartzose biotite-granite, except a small area in Sections 3 and 34, where it is a felsitic (?) breccia. The breccia is silicified by solfataric action at the corner near Shaft No. 7, in Section 34; but this action is older than the sands and does not extend to them. The shaft averaged 50c. per ton, more than twice as much as the rest.

This result is excluded from any of the estimates of the total value of the ground. West of the camp, immediately beyond a narrow rim of granite, there is a reddish rhyolite outcrop.

I carefully noted the character of the sands, and found them an ordinary mixture of quartz, feldspar, and biotite; brown when dry, bluish when wet; and concluded that on the whole they were derived from degradation of the granite rim-rock. The feldspars are usually entirely altered, but the mica—black, shining, unoxidized biotite—is remarkably persistent. This suggests that the detritus is volcanic ash; but the biotite in the granite rim-rock has the same characteristic resistance to decomposition. Even in the granite subjected in the past to solfatarism, which produced a complete alteration of the feldspar, and a partial one of the quartz, the bright biotites remained. Except in some unusual places I did not see any suggestion in the arrangement or character of the deposit that it was tuff. In these places the material was very fine, and may well be granite slime. The beds range from clay to coarse sand, but not gravel.

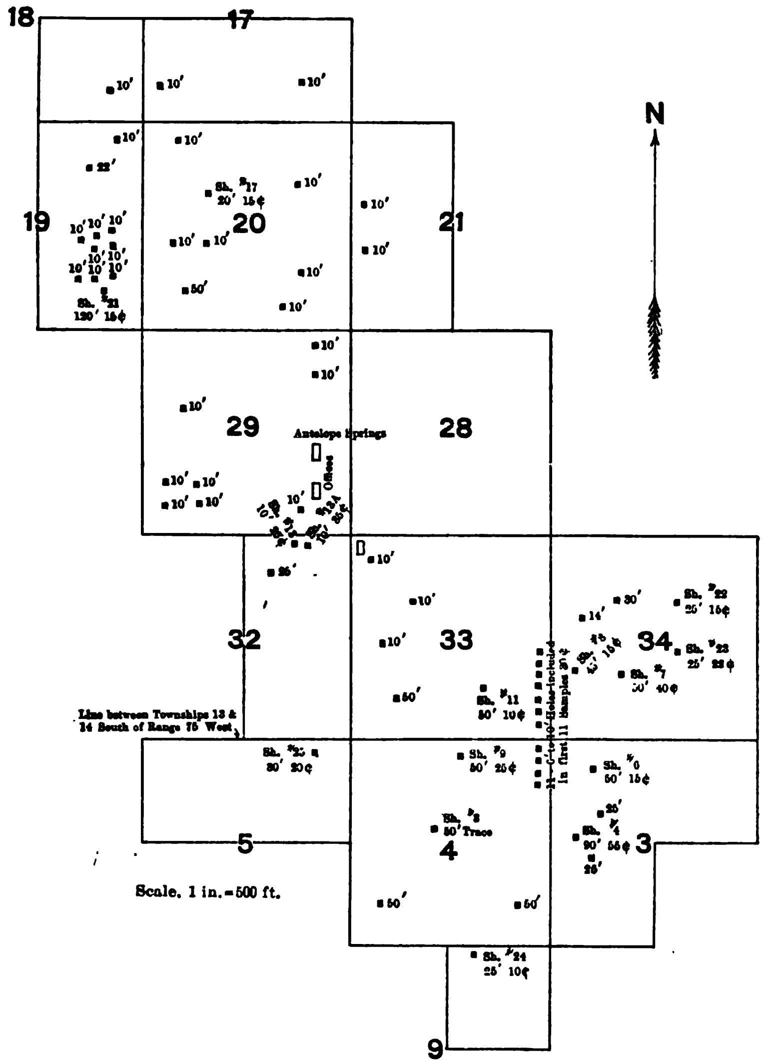
A distinction had been made by prospectors between the brown and the blue sands; but they are the same in composition, and there is no unconformity between them, or anything to indicate that they were laid down at different periods, or under different conditions. The brown is the dry sand slightly stained with iron oxide; the blue, the damp sand near permanent water-level.

Interest had also been felt in the "fines," or that portion of sand which as dug would pass a 4-mesh screen. These fines are the looser material in the homogeneous mass of sand, or the part loosened by abrasion in breaking the ground, and are not seams of sand in gravel or breccia. From my samples, the fines were screened and quartered down separately, and were found to carry just the same amount of gold as the sands.

I watched carefully, but could not find any areas or strata of concentration. There is but a small range of value in the samples (from 10c. to 40c. per ton); and the total average is 20c. per ton. The only high assays were from Shaft No. 7, at the silicified area already noted, and are excepted from the estimate.

The map, Fig. 1, shows that the shafts and cuts are scattered

so as to prospect the ground thoroughly. Besides 11 pits, from 6 to 10 ft. deep, in Sections 4 and 33, there are 55 shafts, aggregating 1,375 ft. in depth, of which 32 are 10 ft. deep, and



NOTE.—Samples were taken from only the numbered shafts.

FIG. 1.—SKETCH-MAP OF TEST-SHAFTS NEAR ANTELOPE SPRINGS, PARK COUNTY, COLO.

two are respectively 90 and 120 ft. deep. Altogether the average depth is 25 ft. Some of these shafts were full of water, or otherwise inaccessible. From shafts and dumps I

was able to sample satisfactorily 15 of them, aggregating 650 ft. in depth. The shallow pits in Sections 4 and 33 were also sampled.

It would have been an easy matter for some one to salt such sands as were sampled; hence, much precaution was observed. In sampling the shafts, six continuous cuts were made, four on the sides and two on the ends. Each sample consisted of 6 or 7 ft. in height of these cuts, so that three samples for assay would be made from a shaft from 20 to 25 ft. deep. Before making the sample-cuts, a much larger mass of the material was stripped down to obtain fresh surfaces. The samples taken weighed 3.5 tons; the material first removed to obtain these weighed probably 14 tons. To find out whether the fines (or sands which as broken would pass a 4-mesh screen) contained more gold than the coarse, each of the samples (4,037 lb. of the original weight of 7,062 lb.) was screened through a 4-mesh screen, resulting in 2,723 lb. of oversize and 1,314 lb. of undersize; 50 samples had been taken, given 50 oversize and 50 undersize assays; and both classes averaged the same (20c. per ton), exclusive of Shaft No. 7. It was also hoped that this division would help to expose any preliminary salting. If the samples had contained gold in paying quantity, further investigation would have been made, but being worthless, the matter was dropped.

The 100 samples, 50 oversize and 50 undersize, were given to three Denver assayers for as careful determination as ordinary prices would allow. One office returned a "trace" on 33 of the samples, and the assayer, on inquiry, said that the trace was about 25c. or less; the other two assayers, Messrs. Stephen Rickard and J. H. Richards, averaged 20c. on the other 66 samples, exclusive of Shaft No. 7. These gentlemen used respectively duplicate half assay-tons and whole assay-tons in the determinations. A synopsis of these results is given in Table I. and Fig. 1. The value is pretty evenly distributed throughout the ground. From these returns it seems safe, in figuring on the "ore in sight" (which in this case is not ore at all), to estimate a block of ground, 5,000 acres in area, and 50 ft. deep, at 25 cu. ft. to the ton, equals 435,600,000 tons, at 20c. per ton, equals $87,120,000, and this is only a small portion of the lake-bed area; but let me quickly add that even if my

sampling was correct, and this gold is existent, it is as elusive as the gold in sea-water. It would cost, including losses, several times as much as its value to obtain it.

I took a "grab" part of each of the 50 pulverized undersize samples, making a composite sample, and panned it. The slimes assayed 40c., middlings 10c., and concentrates a trace, per ton. Too much confidence must not be placed on such results from a single sample, no matter how carefully taken. It is a series of samples, balancing errors, that counts. I also took carefully three one-eighths of an assay-ton, as if for assay, from the same slimes, middlings, and concentrates, and examined each microscopically, with from 40 to 70 diameters, expecting to find colors of gold, but failed to do so. The gold of Snake river takes 1,000 to 1,200 colors to make a cent, and would have been easily visible under the circumstances. Further attempts to "chase down" this gold are left to a wiser man.

None of the shafts are down to bed-rock, but there is nothing to indicate that the bed-rock will be richer than the sands above it, although the sands are probably richer than the rim-rock from which they are derived. No concentration of any kind was found in the beds; and, judging from panning-tests, none of the gold is free. I did not make these tests, but while the development of the ground progressed, the superintendent and the foreman panned constantly without finding any appreciable colors. They undoubtedly tried carefully and skillfully, being anxious to find gold. I thought the lack of free gold, and consequently of concentration, was due to the peculiar resistance to alteration of the iron silicates, and that if these silicates had released the gold the resultant exhibit would have been similar to the gold of Snake river, Idaho; but the higher value of the slimes, containing a modicum of unaltered biotite, has confounded this idea.

TABLE I.—*Value of Gold in Sands.*

Description.	Oversize. Ct.	Undersize. Ct.
Composite sample from four of the six pits in Sec. 33; the individual samples were unfortunately put together, .	40	40
Composite sample from pits Nos. 5, 6, and 7 in same place, ...	20	30
Composite sample from pits Nos. 8, 9, 10, 11 in same place, ...	20	20

Description.	Oversize. Ct.	Undersize. Ct.
Shaft No. 4, full of water, sample of half the dump,	60	50
Shaft No. 3, inaccessible. Sample of one-quarter of the dump,	trace.	
Shaft No. 13,	20	30
Shaft No. 13A,	50	20
Shaft No. 7, average of 6 samples,	30	50
Shaft No. 22, two samples of bottom 14 ft. to timbers,	20	15
Shaft No. 23, two samples of bottom 14 ft. to timbers,	20	15
Shaft No. 8, four samples of bottom 28 ft. to timbers,	20	15
Shaft No. 6, three samples of bottom 21 ft. to timbers,	15	20
Shaft No. 9, six samples of bottom 38 ft. to timbers,	25	25
Shaft No. 24, two samples of bottom 14 ft. to timbers,	10	10
Shaft No. 21, full of water, sample of one-quarter of the dump, average of three from bottom of trench, 27 ft. long, 2.5 ft. deep, 1,200 lbs.,	15	10
Shaft No. 11, 50 ft. deep, tightly timbered for 27 ft., three samples from bottom 23 ft.,	10	10
Shaft No. 17, 20 ft. deep, two samples covering 8.5 ft., skipping timbering, from bottom to surface-soil,	15	15
Shaft No. 25, 30 ft. deep, two samples of bottom 10 ft.,	20	20

I chipped off 250 small pieces from four areas of the rim-rock, 0.75 mile apart, on the west side of the ground of the company. At each place these pieces were taken from granite outcrops, dotted over 5,000 sq. ft.; the sample was carefully assayed and yielded only a trace of gold. The resulting button from two assay-tons looked very nicely under a Coddington lens, but it did not appreciably move the scales, though it was said they would weigh down to 10c. per ton if one assay-ton were used.

In taking the chips, slips showing quartz-seams and aplitic intrusions were avoided. To find out about such material, I took 50 chips from an island, rising out of the lake-bed, 1.5 miles south of the camp and springs. These scattered croppings, 200 by 100 ft., seemed to have been originally an aplitic type of the general granitic country; they are now somewhat secondarily silicified. The sample assayed 10c.; three others tried at the same time gave no gold. The assayer said that others besides myself had brought in Hartsel lake material, and the sands always contained gold, though sometimes the country-rock did not.

The story is interesting as indicating one of those virginal sources of supply from which nature has elsewhere gathered

the metals for payable deposits. Gold in granite is not unique. W. P. Blake[1] cites S. F. Emmons, G. P. Merrill, J. E. Spurr, and himself, as discoverers. It was found by A. Simundi in the general mass of the granite of the Carson district, at Silver City, Owyhee county, Idaho,[2] and by others in various places.

It is from such sparsely mineralized areas that the metallic values are thought by some geologists to be gathered into pay-veins, where both gold and quartz result from magmatic differentiation, as opposed to solfatarism. The dividing-line between deposition by the two phenomena is probably a matter of personal opinion or bias. So far, observation of such processes in action covers only both extremes—dikes with a small percentage of water, and attenuated waters, the solid contents of which would do no more than form a film on their channels of passage.

Reasoning upon an ordinary commercial quartz-vein as a product of magmatic segregation, there is only required a concentration of silica from the original magma of three into one; but if the vein carries $7.50 per ton in gold, and the original magma 10c. per ton, and 5c. is left behind, there would be a gold-concentration of 150 into one.

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[1] Gold in Granite and Plutonic Rocks, *Trans.*, xxvi., 290.

[2] *Report of the Tenth Census*, vol. xiii., p. 54 (1880).

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Origin of Pegmatite.

BY JOHN B. HASTINGS, DENVER, COLO.

(New York Meeting, February, 1908.)

THE occurrence of such a large amount of gold in the Hartsel granite, even though the surmised existence of similar areas is not new, brings freshly to mind the pegmatite type of magmatic differentiation lately brought again to attention by occurrences at Silver Peak, Nev., described by Spurr; and in Alaska, described by both Spurr and Brooks. In both localities granitic rocks or dikes are thought to pass into metalliferous quartz-veins.

An interesting association in this connection is the occurrence of diamonds in residual pegmatitic clay of San Juao de Chapado, Brazil, described by Derby:[1]

(P. 142) "Bodies of pegmatite are quite common in the older rocks of Brazil, both in the diamond regions and elsewhere, occurring not only in the gneiss and granite, but in the schistose series as well. Those that have been examined are dike-like in their mode of occurrence and granitic in composition."

(P. 143) "The question of the eruptive or secretionary origin of pegmatites has long been a subject of discussion among geologists. . . . The recent studies . . . seem to have clearly established that most if not all of them are essentially eruptive masses, though possibly modified in some way by aqueous agencies. Even before becoming acquainted with the literature of the subject this view had seemed to me to be the only acceptable one as regards the typical pegmatites of Brazil."

What is pegmatite? J. F. Kemp says:[2]

". . . veins or dikes—it is an open question which is the more correct term—are met formed of very coarsely crystalline aggregates of the same minerals that constitute granite. These are called pegmatite and in them is the home of graphic granite, the curious intergrowth of quartz and feldspar, such that a cross fracture of the blades of quartz suggests cuneiform characters. . . . In regard to the larger veins or dikes it seems improbable that true igneous fusion could have afforded such coarsely crystalline aggregates, and so we are forced to assume such abundance of steam and other vapors, *i.e*, mineralizers, as to almost, if not quite, imply solution."

[1] Brazilian Evidence on the Genesis of the Diamond, *Journal of Geology*, vol. vi., pp. 121 to 146 (1898). [2] *Handbook of Rocks*, 1st ed., p. 31 (1896).

A. Geikie,[3] quoting Fouqué and Michel-Lévy, and de Lapparent, says:

"Where the quartz and feldspar of a granitic rock have crystallized in one common direction, one within the other, the structure is pegmatitic where visible to the naked eye, and micro-pegmatitic where the aid of a microscope is needed."

J. P. Iddings's definition in part is:[4]

"The amount of individualized inclusions in a crystal is often so great, that one may speak of a mutual penetration of two or more materially and morphologically different substances. Such a mutual penetration of quartz and acid feldspars is especially common; it presents a peculiar appearance, characteristic of certain members of the quartz-porphyry group, and is the so-called micropegmatite or granophyre structure. The same intergrowth is frequently observed between members of the feldspar group (microcline, albite, orthoclase) in the older massive rocks, where it is usually controlled by rigid mutual crystallographic relations. The basic massive rocks also exhibit similar phenomena, as, for example, when the larger porphyritic augites are so filled with apatite, magnetite, mica, nepheline, haüyne, etc., that the augite substance only forms a cement, as it were, for the different minerals. This structure has been called poicolitic."

Its microscopic features are, Hague and Iddings say:[5]

"*Pegmatoid.*—The structure produced by the intergrowth of two or more minerals, usually quartz and feldspar, in such a manner that when seen in thin section they appear as groups of grains of more or less regular form, each group having one optical orientation throughout. It is similar to the structure in graphic granite."

The same properties, with other and familiar names, are described by E. Haworth[6] in discussing the structure of the holocrystalline groundmass of porphyries, who says:

"The following is taken from the lecture notes of Prof. G. H. Williams: . . . In the second place a granular effect may be produced by the complete interpenetration of two individual crystals of the same size. In this case—due to the simultaneous crystallization of the two minerals from the magma—all the parts of the same individual, no matter what the size or shape, must have exactly the same optical orientation, and must hence extinguish the light between crossed nicols together. Such a structure is termed, according to the particular form it assumes, micropegmatitic or granophyric."

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[3] *Text-Book of Geology*, 2d ed., p. 109 (1885).

[4] Rosenbusch, *Microscopical Physiography of the Rock-Making Minerals*, p. 19 (1888).

[5] On the Development of Crystallization in the Igneous Rocks of Washoe, Nevada, *Bulletin No.* 17, *U. S. Geological Survey*, footnote, p. 14 (1885).

[6] A Contribution to the Archæan Geology of Missouri, *American Geologist*, vol. i., p. 367 (1888).

This structure is quite common; quotations like the following are often seen. N. H. Darton,[7] after examining thin sections of granite from Montana areas, says:

"Micrographic intergrowth of quartz and feldspar is common, and secondary minerals frequently occur along the cleavage cracks of the latter."

Arrhenius, as quoted by Vogt,[8] discussing pegmatites, begins at the beginning, and, presuming an interior gaseous earth magma, says, in effect, that so far as we know these gases are primarily homogeneous, and if they contain water (vapor), on ascension as plutonic magmas and consequent degree of cooling would separate into less and more aqueous segregations, especially at contact with the cool inclosing rock, the separation becoming ever more marked, and the aqueous part more mobile. Then:

"By reason of the greatly superior mobility of the aqueous solutions, as compared with the magma, these segregations may send out branches in the form of the finest apophyses. The solution in aqueous gas now gradually cools, and one substance after another separates from it. By reason of the great mobility of the solution, and its consequent strong capability of diffusion, the minerals (provided the cooling be not too rapid) are segregated in large crystals, such as characterize a so-called pegmatitic structure. Gradually, also, the constituents which longest retain a gaseous form—such as water and carbonic acid—escape."

This seems closely akin to solfatarism, and the product, if seasoned with metallics and garnished with walls, should make a desirable vein. In descriptions of pegmatites it is sometimes hard to understand just what is really meant regarding "solutions," now that the term is applied to ordinary liquid magmas.

Pegmatites are plentiful in Norway and Sweden, and Prof. Hjalmar Sjögren[9] describes them:

"These pegmatites are to be considered as secretions with a low temperature of crystallization, deposited from aqueo-igneous solutions in contraction-fissures due to the cooling of the surrounding rocks."

Waldemar Lindgren's[10] version, about pegmatites in general:

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[7] Geology of the Bighorn Mountains, *Professional Paper No.* 51, *U. S. Geological Survey*, p. 19 (1906).

[8] Problems in the Geology of Ore-Deposits, *Trans.*, xxxi., 133 (1901).

[9] The Geological Relations of the Scandinavian Iron-Ores, *Bi-Monthly Bulletin*, No. 18, November, 1907, p. 884.

[10] Relation of Ore-Deposits to Physical Conditions, *Geological Congress, Mexican Meeting*, 1906.

" . . . made by aqueo-igneous solutions, pegmatite dikes . . . pegmatite formation evidently requires very high temperature, and the conditions are decidedly deep-seated."

This shows a slight difference of opinion; in fact, to get a fair knowledge of the habits of pegmatites and theories of their origin it is necessary to read a number of descriptions; the following, arranged about chronologically, are the most important that I have seen in recent American literature, and probably cover quite well the diversities of occurrence, and are given either verbatim, in quotation marks, or without them, but closely following the language of the authors:

Sterry Hunt[11] makes a strong case for so-called pegmatitic veins in eastern Canada and the northeastern United States.

He thought them, in common with other geologists at that time, segregation-veins, or concretionary, as he preferred to call them, and describes dikes and veins of granite, and says the latter are distinguished by containing boron, fluorine, phosphorus, etc., and by successive deposition generally in open fissures, showing persistency of the banded structure, each consisting of different minerals or association of minerals deposited slowly and successively from aqueous solution.

For instance:

(P. 194) "At other times pure vitreous quartz forms one or both walls, or the centre of the vein, or else is arranged in bands parallel with the sides of the vein, and sometimes a foot or more in thickness, alternating with similar bands consisting wholly or in great part of orthoclase, or of an admixture of this mineral with quartz, having the peculiar structure of what is called graphic granite, or else presenting a finely granitoid mixture of the two minerals, with little or no mica, and with small crystals of deep red garnet."

The widths varied from a few inches to 60 ft. These veins also contained the rarer minerals. Experiments of Schafhautl and Wohler, which show that quartz and apophyllite may be dissolved in heated water, under pressure, and recrystallized on cooling, are also alluded to.

Coming after Hunt, and perhaps the first of American geologists to apply microscopic study to pegmatites, was G. W. Hawes.[12]

[11] Granites and Granitic Vein-Stones, *Chemical and Geological Essays* (1874).

[12] *Geology of New Hampshire*, vol. iii. (1878).

Describing the granites of New Hampshire:

(P. 201) "Another of the hornblende rocks . . . is very peculiar in its microscopic structure. Macroscopically, this rock is fine in texture and dark in color, and its individual constituents cannot be determined. Under the microscope its thin sections show that the dark constituent is greenish hornblende, though it is partially altered into epidote and chlorite; but the circumstance of note is, that many of the minute grains of feldspar are inlaid with quartz in the manner peculiar to graphic granite. The rock is hence a kind of microscopic pegmatite. The figures that are formed are often of rare perfection. Michel-Lévy found this character in quite a number of French granites. . . . The pegmatitic character of a rock he regards as evidence of the simultaneous crystallization of quartz and feldspar."

Referring to the immense beryls found in New Hampshire:

(P. 68) "The beryls are found in granitic veins. The veins are easily recognized by the very large crystals of quartz, feldspar, and mica, which are the constituents of ordinary granites; and the general presence of beryls in them is interesting as substantiating the theory of their formation. These granitic minerals occupy large fissures, and it is thought that water, which had filtered through the surrounding rocks, and which, under a high pressure, and at a high temperature, had become saturated with their soluble constituents, deposited these great crystals of the various minerals in these fissures, until they were finally filled with this extremely coarse granitic mixture. In this way the rarer elements, such as glucinum, which exist in such minute amounts in the surrounding rocks, became concentrated in these veins, forming the beryls that are so common there."

This is a lucid description of the former lateral secretion theory as applied to pegmatites, which was in general belief twenty or more years ago; since then so much has been learned of the character of veins that perhaps these views are not held at all now in the United States.

G. H. Williams,[13] describing the associated rocks of the crystalline belt near Baltimore, Md., says:

(P. 14) "Huge veins of a coarse-grained pegmatite, which both in their form and in their structure closely resemble intrusive rocks, are also frequently found intersecting the schists and gneisses. As far as my observation extends, the character of these granites seems quite independent of the rock in which they occur. Whether in the lightest, most acidic gneiss or in the darkest hornblende-schist, the coarse-grained aggregate of muscovite, microcline, albite, and quartz appears in all respects the same."

(P. 25) "Accidental minerals are rare in the Baltimore gabbros. At some localities vein-quartz—evidently a secondary infiltration into existing cracks and fissures—is abundant. Long crystals of black tourmaline, forming radiating groups sometimes two feet in diameter, are found imbedded in this quartz. . . .

[13] The Gabbros, etc., in the Neighborhood of Baltimore, Md., *Bulletin* No. 28, *U. S. Geological Survey* (1886).

"Associated with this quartz, west of Mount Hope Station and along Gwynn's Falls, north of the Liberty road, are many blocks (float? J. B. H.) of a coarse-grained muscovite granite or pegmatite, which is to all appearances identical with that occurring so abundantly in the gneisses. This rock is composed of a flesh-colored microcline, white albite, quartz, and muscovite; garnet and tourmaline are also not rare constituents. The occurrence of this pegmatite, so rich in alkalies, in the center of the gabbro area, may be regarded as a fact in favor of its exotic nature so far as it shows that this rock is not dependent upon the nature of the inclosing mass, as might naturally be expected to be the case with segregation veins."

The following description by Prof. W. P. Blake[14] has an added interest because the pegmatite is an ore (?) deposit, and in structure forms a connecting link with tin-veins.

Describing the Black Hills tin-veins: The Etta is a granitic mass in fine-grained slates, about 200 ft. to 100–150 ft. The mass crystallization is extremely coarse; slabs of pure feldspar from 12 to 20 in. long and masses of white quartz several feet thick are abundant:

(P. 692) ". . . the outer portions, next to the country rock, being characterized by a band or belt of dark-colored mica, alternating in places with muscovite in large plates. This is succeeded by massive quartz, with irregular bunches of massive albite and of orthoclase feldspar, together with enormous crystals of spodumene and irregular bunches of a dense aggregation of small crystals of mica and albite, forming a kind of greisen-rock, an albitic greisen, in which cassiterite is abundantly disseminated in small grains and partly formed crystals."

(P. 695) "In the numerous tin-veins and tin-ore-bearing granitic dikes of the Black Hills tin-region, the phenomena of occurrence and association indicate that all of the minerals of the dikes—the quartz, feldspar, spodumene, mica, beryl, columbite, tantalite, phosphates, and other associates of the cassiterite, were contemporaneous in origin. The tin-stone is apparently as much a part of the mass as the mica or quartz. It was, to all appearance, present when the whole mass assumed its crystallization. All the constituents of the dike appear to have crystallized from a semi-fluid or pasty magma, in which the elements were free to arrange themselves from one side of the dike to the other and to crystallize out slowly."

No crustification, alteration, replacement, or solution, no fluorine. The rude parallel structure seems due to different conditions of pressure or temperature next to the walls while the fissure was full of the unsolidified constituents.

H. W. Fairbanks,[15] on southern California pegmatites:

"On the eastern slope of this hill is an enormous pegmatite vein, carrying a very interesting set of minerals. This vein is twenty or more feet wide, and dips

[14] Tin-Ore Veins in the Black Hills of Dakota, *Trans.*, xiii., 691 to 696 (1884–85).

[15] *11th Annual Report, California State Mining Bureau*, p. 94 (1890–92).

west at a small angle. There are masses of great size of almost pure mica and feldspar, or quartz and feldspar—in the latter case very fine specimens of graphic granite have been formed. Near the southern end of this vein is a deposit of lepidolite mica, 10 feet thick at the widest part, and appearing in detached bodies for several hundred feet. It is fine-grained and shows a pale purple color. In places it is pure, in others filled with large radial aggregates of pink tourmaline (rubellite). Some of the aggregates are a foot across, others are long and slender, with arborescent forms. North of the main deposit it is found in quartz in fan-shaped aggregates, the crystals being more than a foot long, but greatly decomposed. Black tourmaline is abundant in the pegmatite surrounding the lepidolite, but in poor, brittle crystals. Garnets are also to be found in places. The vein as a whole is inclosed in the diabase."

G. H. Williams on the origin of Maryland pegmatites: [16]

(Footnote, p. 675) "The term 'pegmatite' was first suggested by Haüy in 1822 for those regular intergrowths of quartz and feldspar which are now designated 'graphic granite.' In 1849 Delesse extended its use over all the very coarse granites. He was followed by Naumann in his *Lehrbuch der Geognosie*, and since that time the word pegmatite has been generally adopted for this entire group of coarse-grained granitic rocks, and even for the corresponding equivalents of other plutonic masses, as for instance syenite-pegmatite, diorite-pegmatite, gabbro-pegmatite, etc."

(P. 675) "Another important group . . . largely developed in Maryland . . . embraces the very coarse-grained aggregates of quartz and feldspar, with more or less mica, variously known as pegmatites . . . they are among the youngest of the products of granitic intrusion, and hence show little or no effect of dynamic metamorphism. . . .

"Pegmatites are . . . abundant all the way from Newfoundland to Alabama. . . . Many of the districts in eastern United States which have become mineralogically famous are great pegmatite dikes."

(P. 676) "Élie de Beaumont . . . accepting in the main the igneous and intrusive origin of pegmatites, introduced an important addition in assuming water and other mineralizing agents as necessary factors in their formation. He correlated the pegmatites with the other phenomena so common in the peripheral regions of granitic districts, or, as he called it, 'granite aura' (the penumbra of Von Humboldt). De Beaumont, while assuming granitic emanations as necessary for the crystallization of the coarse-grained granites, is careful to distinguish between them and the banded concretionary veins formed by substances dissolved in circulating heated waters. . . .

"The intrusive theory of the origin of pegmatite, with the aid of water and other mineralizers as important factors, has been recently advocated by J. Lehmann and by Brögger, and may be regarded as the most acceptable for all those masses which are in intimate association with larger plutonic intrusions."

(P. 678) "Only by assuming that they have attempted to cover by a single explanation a number of similar rocks which are genetically distinct is it possible to account for so many competent observers having arrived at such diverse conclusions regarding the origin of pegmatites. . . . The writer's studies in Maryland have led him to believe that both segregation and intrusive pegmatites, quite similar in appearance, appear side by side."

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[16] General Relations of the Granitic Rocks in the Middle Atlantic Piedmont Plateau, *15th Annual Report, U. S. Geological Survey*, pp. 657 to 684 (1893–94).

Illustrative of the two forms of pegmatite in the Piedmont Plateau, there is, first, an immense amount of white vein-quartz, seaming and penetrating the schists in all directions, from minute isolated eyes to large lenticular masses, and veins continuing for a considerable distance, occasionally containing original tourmaline and flesh-colored feldspar, and, rarer, mica, etc., all formed by segregation from the inclosing rock-sheared gneisses. Secondly, there are the dikes composed of quartz, microline, albite, muscovite, and occasional small patches of red garnet (no biotite was observed), similar to but more acid than the main mass of the granite, that are plainly eruptive. Their size and abundance are proportional to their nearness to some eruptive granite mass with which they essentially agree in chemical and mineralogical composition, and they are quite independent in character of other rocks in which they may be inclosed. They are not, as a rule, either drusy or symmetrically banded, though frequently finer grained toward the edge.

(P. 684) "The writer therefore interprets those pegmatites which by their mode of occurrence and association strongly indicate an igneous character as the products of the residual and therefore most acid portion of a granite magma highly charged with water and other mineralizing agents. Such a siliceous material, in a state intermediate between fusion and solution, has been injected into fissures and there crystallized into very coarse-grained aggregates, not necessarily through any great slowness of this process, but rather in virtue of the aid to crystallization afforded by the abundance of mineralizers present."

The very fine illustrations accompanying the paper show typically appearing dikes.

Messrs. Crosby and Fuller[17] (of which the following are extracts and principles), complementing the work of Williams, have together with that author supplied the views in the leading treatises on the subject in the United States, for the past ten years, and perhaps still supply them, though largely supplemented by the monograph on Silver Peak, Nevada, by J. S. Spurr.

(P. 327) "The modern conception is that in a broad view the pegmatites are igneous rocks, but it is the part which water has played in their formation that has so strongly differentiated them from other igneous types . . . the chief purpose of this paper is a contribution to the aqueo-igneous theory."

Pegmatite has been employed to designate both the macro-

[17] Origin of Pegmatites, *Technology Quarterly*, vol. ix., pp. 326 to 356 (1896.)

and micro-pegmatitic structure, also plutonic rocks distinguished by a gigantic scale of crystallization. Pegmatites range from highly acidic (quartz) to ultra-basic varieties, and differ from normal plutonics texturally, rather than mineralogically; we herewith deal with the acid pegmatites.

(P. 328) "The essential species include quartz; the acid feldspars—orthoclase, oligoclase, albite, and microcline—the last two being especially characteristic; and the more acid micas, including muscovite and lepidolite, and, less characteristically, biotite."

The accessory minerals are numerous and include many rare species. The quartz, as in granite, contains numerous inclusions of water and carbon dioxide, in one instance in proportion of 1–1, indicating crystallization under enormous pressure. We abundantly confirm Williams that typical pegmatite masses pass into pure quartz and ordinary quartz-veins. We disagree with his belief that their origin is different, and feel that quartz-veins are the possible end-product of differentiation that yields pegmatites. At Narraganset Bay mica-schists contain typical pegmatite veins 5 to 60 ft. wide; a mile east, veins in the schist are quartz, with some feldspar but no mica, while on another island they are quartz alone. Pegmatites occur in all formations, but—

"In every pegmatite district there is one normal plutonic rock of essentially similar but slightly less acid composition, with which the pegmatite is most intimately associated, into which it may often be traced, and from which it has evidently been derived."

The pegmatites most often in the district studied penetrate schists composed chiefly of silica and alumina, and have absorbed portions of them, producing as a result more quartz and muscovite, the latter being an aluminous silicate. The pegmatite-mines of New Hampshire are in such schists. Perhaps tourmaline pegmatites generally were formed the same way. Pegmatites apparently carry more unusual minerals than the parent rock, but this is probably due to differentiation into tangible local accretions, as the total contents of magma and dike agree chemically. While the texture of the pegmatites may be as fine as the parent plutonic, they are on the whole characterized by their coarseness, beryls from a foot to a yard in diameter, spodumenes from 10 to 30 ft. long, feldspars 10 to 20 ft., and

other crystallized silicates occur, beautifying the best cabinets. The smaller veins, 2 to 20 ft. wide, are often coarser-grained than the greater ones. The minerals crystallize in the same order and manner in the pegmatites as in the plutonic—tourmaline and other basic species, biotite, muscovite, basic feldspar, acid feldspar, and quartz. The earlier minerals are approximately idiomorphic, the quartz allotriomorphic. In the vugs, however, the order is changed, except for tourmaline and ultra-basic minerals, and albite is often seen in tabular crystals implanted with muscovite.

(P. 334) "Notwithstanding the lateness of its crystallization, the quartz not infrequently forms immense vitreous masses, and these often pass into veins of quartz, or quartz and accessory feldspar, intersecting the normal pegmatite as well as the country rock, thus testifying clearly to the extremely acid character of the magma residuum."

Continuous crystallization is abundant in all the larger masses, that of the later species having begun before the earlier ceased. Intergrowth of quartz and feldspar is frequent, and perthitic intergrowth of the feldspars similar in structure to graphic granite also occurs, but the ideal pegmatitic development of the latter is rare.

(P. 334) "Rosenbusch has sagaciously correlated the pockets and druses with the miarolitic structure of the normal plutonics—a feature of like significance, but developed, like the crystallization, on a grand scale. . . .

"The pegmatite masses, like true dikes, are frequently fine-grained next the wall, becoming rapidly coarser toward the center."

The fine-grained portion sometimes grades into the parent plutonic wall-rock without line of demarcation. A cross-section from a well-defined pegmatite vein, 6 in. wide,—

(P. 335) "is made up of two sharply defined and symmetrical bands or layers of albite (clevelandite), with the tabular crystals set edgewise to the walls and a median band of smoky quartz; while springing directly from either wall and penetrating both the albite and quartz are numerous slender prisms of green and red tourmaline.

"The disposition of the tourmalines noted above is highly characteristic; and may be observed in many massive or unbanded veins; showing that this comb-structure and a distinct banding are not necessarily correlative, although they are undoubtedly of like significance, testifying with equal distinctness to successive crystallization."

Vugs are sparing here but characteristic in New Hampshire,

where they are large enough to admit of one well-formed quartz-crystal a yard in diameter. These great pockets have indefinite positions and are never peripheral in the vein; in other districts they occur in flatly lenticular form, indistinguishable except mineralogically from pockets of ordinary veins. Wall-rock fragments are common in the pegmatite; the inclusions, schist especially, have a frayed out, skeleton-like appearance, suggesting solvent action; the wall-rock is similarly affected and impregnated with tourmaline and allied minerals. The pegmatites no doubt occupy spaces of discission, and occur in wall-like, lenticular, and horizontal sheets, but a very large proportion are too irregular for any one term.

(P. 337) "They very commonly conform closely with the structure planes of the schistose rocks (interbedded veins); but they also intersect the bedding planes or lamination at all angles; and may in general be assumed to follow lines of least resistance to the disrupting force."

The occurrences in the granite have "parallel sides," generally more "definite angles and general linear character" than in the schist, where the intrusion has evidently often formed for itself spaces of dissolution. The authors say, in effect:

(P. 340) The rare minerals, coarse crystallization, banding and comb-structure, with tourmalines, etc., normal to the walls, inclusions of water in quartz, etc., the pockets and druses of the pegmatites favor an aqueous origin; but the order of crystallization (except in pockets), the completely idiomorphic crystals, the graphic structure and the finer crystallization next the walls, are at least more suggestive of igneous contacts; broken tourmalines, etc., inclined tourmalines, inclusions of carbon dioxide, immense size of many of the veins, evidence of solution of the walls, orientation of inclusions, demand . . . important modifications of the aqueous process.

The granite country is uniform and devoid of pockets.

Brögger is cited that gigantic crystallization and irregular composition is due to slowness of consolidation, the walls being first heated; also that pegmatite dikes are often far away from the parent eruptive.

The authors picture as a parent magma, a deep-seated granite boss cooling from the boundary inwards, and crystallizing with ever-increasing slowness, thus driving the siliceous waters to the center of the mass and there forming the giant crystals. The magma contracts with solidification so the hardened outside crust of the boss and the beds on top may

fissure, and the central magma residuum enter these fissures, forming pegmatite. There should be a gradual transition from the normal granite to pegmatite, and it is thought that a syenite in the vicinity with feldspar crystals 4 to 6 in. long may represent this stage. It is also thought that normal magma often penetrated hot schists and absorbed water from them, adding to its own liquidity, which enabled the formation of pegmatite. The pegmatites are believed to have been formed at great depth.

A. Mervyn Smith,[18] describing Indian pegmatites, says:

The veins range from a mere thread to 20 ft. wide, and occur parallel to the bedding of a mica schist. The veins are made up of amorphous masses of quartz, large crystals of pink orthoclase, and crystals or books of muscovite. When the walls are quartzitic the vein-stuff is nearly pure quartz; when highly feldspathic, pink feldspar crystals are the chief constituent; when micaceous, mica predominates. Such occurrences were probably responsible for the lateral secretion theory.

F. D. Adams,[19] describing nodular granite from Pine Lake, Ont., says in effect:

The nodules were "schlieren" rich in silica and alumina, with boracic acid, and during the general cooling of the magma developed a spherulitic arrangement, often with tourmaline towards the center, and sometimes arranged themselves in a string, vein fashion. It is unknown how they first came into existence, but:

(P. 171) "We have, however, examples of such differentiation in granite magmas in the case of pegmatite veins, which at their extremities frequently run out into veins of quartz associated with a little tourmaline."

(P. 172) ". . . but the study of this occurrence shows that 'contemporaneous veins' of an acid character may be formed not only during the final stage of crystallization, as in the case of the hysterogenetic schlieren and the 'kluftblätter' of Reyer, but that highly silicious portions are sometimes segregated or differentiated out of a granite magma before crystallization, and that the banded structure often seen in pegmatites and other allied bodies and sometimes cited as proof of their aqueous deposition in preëxisting fissures is not necessarily so produced, but, as is now being generally recognized, may and usually does result from the primary crystallization of the cooling magma."

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[18] Mica Mining in Bengal, India, *Mineral Industry*, vol. vii., p. 512 (1899).

[19] Nodular Granite from Pine Lake, Ont., *Bulletin of the Geological Society of America*, vol. ix., pp. 163 to 172 (1897).

J. F. Kemp,[20] cites a variation of the common minerals, near Port Henry, N. Y.

(P. 183) "Near the ore are also met coarse aggregates of hornblende, plagioclase, magnetite and quartz in the nature of pegmatites."

The ores are thought to be contact-deposits, though obscure; there is an almost total absence of sulphur.

H. B. Patton,[21] describes the strongly tourmalitic type in Colorado.

(P. 26) "The pegmatite veins of these foothills are usually composed of coarse granular aggregates of reddish microcline and quartz, with or without muscovite, and occasionally garnet. They frequently resemble segregation veins in that they shade off into the adjoining schists without any well defined vein wall. . . . It may be an intrusive dike, but in the opinion of the writer these and other pegmatite veins of the region are not of such origin."

The tourmalines occur:

(P. 21) "Beautiful lustrous black crystals, often two or more inches in diameter, have been obtained from these pegmatite veins."
(P. 22) "One may see . . . numerous veins . . . of quartz and feldspar containing the habitual black tourmaline."

First locality—an 18-in. vein of quartz and tourmaline:

"The tourmaline . . . is a fine grained schorl-like mass more or less banded with white vein quartz . . . tourmaline predominates over quartz . . . not as . . . grains or crystals, but rather in a dense felted mass . . . banded structure . . . is usually very marked . . .

"A thin-section . . . discloses . . . granular quartz, . . . prisms . . . and . . . grains of tourmaline, . . . a very little muscovite."

Second locality:

". . . a pegmatite vein about 10 feet wide. . . . The tourmaline, which is to be found only sparingly in the vein itself, occurs impregnating the schists at contact with the vein. . . . the schists . . . lose in places all traces of the original cleavage, and develop into aggregates of quartz and tourmaline to the entire exclusion of the mica. . . .

"The tourmaline has evidently been formed at the expense of the biotite."

J. F. Kemp,[22] on the Atlantic Coast granites in general, says:

[20] Geology of the Magnetites near Port Henry, N. Y., etc., *Trans.*, xxvii., 146 to 203 (1897).

[21] Tourmaline and Tourmaline Schists from Belcher Hill, Colo., *Bulletin of the Geological Society of America*, vol. x., pp. 21 to 26 (1898).

[22] Granites of Southern Rhode Island and Connecticut, etc., *Bulletin of the Geological Society of America*, vol. x., pp. 361 to 382 (1898).

(P. 372) "The pegmatites are present in great numbers, and at times attain very considerable size. . . .

"The commonest kind is a very coarse aggregate of red microcline, white natron-orthoclase, albite, and quartz, together with a little black, brittle biotite and occasional thin plates of ilmenite and masses of magnetite."

(P. 374) "The proportions of the several minerals in the pegmatites vary considerably, but in the normal specimens one might say that red microcline is most abundant and makes up about 50 per cent. of the whole. Natron-orthoclase and albite follow with about 25 per cent., then quartz, with perhaps 20 per cent., leaving 5 per cent. for all the rest. Quartz may, however, become much more abundant, and instances have been met, as in a large vein near Sachems head, which consists of quartz with but a few feldspar crystals distributed through it."

Then a pure and huge quartz vein, with crustification, is described:

"As earlier stated, Prof. Dana observed that the quartz veins near Stony creek were later than the pegmatites, and it may well be that they mark the closing and fumarolic stages of the intrusive phenomena."

Prof. Kemp had also previously quoted Dana, that the granite (pegmatite) veins cut the quartz-veins when both occurred together.

J. E. Spurr,[23] describing the pegmatoid aplite on Fortymile and Birch creeks, Alaska, says, in effect:

There is about a complete absence of coarse pegmatite, but the fine-grained aplites change gradually in texture to coarse-grained aplites, or fine-grained pegmatites, without change in composition or structure. Sometimes, however, the quartz and feldspar separate, and there will be large bunches of pure quartz and, elsewhere in the dike, coarse-grained aplite, or fine-grained pegmatite. The predominating feldspar is sometimes plagioclase, sometimes orthoclase. In some of these same rocks first the feldspars contract into zones nearest the walls, and leave the central portion pure quartz; then the feldspars disappear altogether and the whole dike becomes solid quartz. The quartz, under the microscope, shows coarsely crystalline interlocking structure, the only minerals beside quartz being a little magnetite and pyrite.

A. H. Brooks[24] found similar occurrences in the Tanana and White River Basins, Alaska:

(P. 463) [Aplite is here used purely in a mineralogic and not in a structural sense.] "This is a massive rock, which when fresh is of an almost pure white color. It is usually medium grained, but is occasionally coarse enough to be called pegmatite. The typical aplite-granite of the region is composed of white feldspar with bluish vitreous quartz. The potash feldspar is orthoclase, sometimes micro-

[23] Geology of the Yukon Gold District, Alaska, *18th Annual Report of the U. S. Geological Survey*, pt. iii., p. 230 (1896–97).

[24] Reconnoissance in the Tanana and White River Basins, Alaska, in 1898, *20th Annual Report of the U. S. Geological Survey*, pt. vii., pp. 425 to 494 (1898–99).

cline, and with it occurs considerable albite. The thin sections of this rock which were examined showed a typical granite structure. It is entirely massive, but in a few instances a distinct parallelism of the mineral was noted, which was undoubtedly an original structure.

"Typically this is a quartz-feldspar rock, but often a little accessory muscovite is present, and it sometimes passes into a muscovite-granite. Apatite is a common accessory mineral, and in some specimens considerable tourmaline was noted. One phase of this rock is scantily sprinkled with small plates of biotite. This aplite-granite has a wide distribution in the White River and Tanana basins, and rocks of a somewhat similar character have been described by Spurr in the Fortymile and Birch Creek districts. I found them cutting not only the gneisses, but also rocks of younger age, as will be described hereafter. They are usually intruded as small dikes parallel to the foliation and bedding planes, but are occasionally found cutting the structural planes."

(P. 484) "*Quartz veins in the older series.*—In the descriptions of the rocks of the region reference has been made to the presence of quartz in the gneisses and the two oldest series of metamorphosed clastics. In the gneissic series the quartz veins are limited to the sheared and schistose phases whose foliation planes afford opportunities for the injection of the quartz-bearing solutions. On the Middle Tanana, where the two shear zones are equally developed, the quartz veins are found in both systems. In the quartz schists and associated rocks of the Nasina series of the Lower White the quartz veins reach a great development; they are found intruded parallel to the foliation, and very seldom cut across it. I noted in this series a close relationship between the quartz and the coarse pegmatite veins, and at a number of localities was able to trace transitions from one to the other. A similar transition has been noted by Spurr in the Birch Creek and Fortymile districts. The quartz veins are most abundant in the Tanana schists, whose finely fissile condition gave abundant opportunity for the penetration of the mineral-bearing solutions. The veins are more widely disseminated in the Tanana schists than in any of the other formations. The greenstone schists show very few quartz veins, for in many cases the rocks are too massive to afford any line of weakness along which the solutions could have penetrated."

J. Barrell,[25] on the pegmatites of the Elkhorn district, Montana:

(P. 518) Describes thin augite-syenite dikes, from a fraction of an inch to 18 in. wide, and as coarsely crystalline for such small dikes, the feldspars being sometimes an inch long. The constituents are orthoclase (largely microcline), augite, and mica. Abundance of water, low percentage of silica, and apparent high liquidity and slow cooling have allowed differentiation after intrusion, so that in patches, a foot or more in length, no augite is present, and surrounding this white nucleus are the panidiomorphic feldspars, thickly charged with augite crystals, making the magma blue-black.

[25] Microscopical Petrography of the Elkhorn Mining District, Jefferson County, Montana, 22*d Annual Report, U. S. Geological Survey*, pp. 511 to 550 (1900–01).

"The segregation has originated therefore, in place and before the beginning of crystallization."

The question of two ages of crystallization, one in the deep before extrusion, the other after the dike magma is in place, is important, especially as to the larger crystallization; on it might depend a decision as to whether the latter was common to a large area of siliceous magmatic differentiation with a moderate supply of mineralizers, or to the influence of a later concentrated supply.

(P. 539) "The aplites, as the term is commonly understood, are rocks of a sugar-granular texture due to a fine-grained, simultaneous crystallization of quartz and orthoclase, the rock consisting of those components with little or no ferromagnesian minerals." . . .

"The aplites are commonly believed to be acid segregations out of the original magma" . . . [76 per cent. of silica.]

(P. 541) An interesting study was made of a thick intrusive sheet between quartz-monzonite and andesite. The aplite showed evidence of chilling against the andesite, and for an inch on the contact is coarse-grained, with quartz and feldspar poikilitically intergrown; then follows several feet of coarse-grained (2 mm. in diameter), characterized by a radiate poikilitic growth of quartz and orthoclase, with less biotite than on the contact.

"A thin section taken 52 inches from the contact showed certain crystals of orthoclase which became poikilitic only after half their growth was completed, indicating a change in the physical conditions at that period, owing to which the quartz and orthoclase could no longer separate themselves from each other during crystallization, and were of simultaneous growth."

At 20 ft. the aplite is normal.

T. L. Watson,[26] after examining the porphyritic granites of Georgia, concludes, after careful study, that the porphyritic feldspars were formed in place and are not a product of earlier crystallization in the depths; they were formed rapidly and are potash feldspars—in all of the sections some of the feldspars show micro-pegmatitic intergrowth with quartz.

A. H. Brooks:[27]

[26] On the Origin of the Phenocrysts in the Porphyritic Granites of Georgia, *Journal of Geology*, vol. ix., pp. 97 to 122 (1901).

[27] Preliminary Report on the Ketchican Mining District, Alaska, *Professional Paper* No. 1, *U. S. Geological Survey*, p. 47 (1902).

"Pegmatitic and aplitic rocks. . . . These have more the appearance of segregations than true injections. In thin section a specimen from one of these was seen to be composed essentially of orthoclase and plagioclase more or less idiomorphically developed, and containing many gas or fluid inclusions, together with allotriomorphic quartz. Muscovite occurred as an accessory mineral. Another occurrence of pegmatite typically developed. . . . Here a coarse, white, pegmatitic rock cuts the greenstone schists. . . . In thin section these pegmatite dikes show an allotriomorphic intergrowth of plagioclase, orthoclase, and quartz. Many of the dikes have been mineralized and much altered. They are frequently brecciated and constitute the host of the ore body."

T. L. Watson.[28] On some Georgia pegmatites.

Stone mountain, residual of a larger mass, is about 700 ft. high (and, judging from the illustrations, three-quarters of a mile in diameter). Aplites are rather scarce and pegmatites common. The latter consist principally of coarse intercrystallizations of feldspar (orthoclase and microcline) and quartz, a little biotite and muscovite, occasionally red garnet and tourmaline; sometimes the pegmatites are replaced by pure quartz. Except for its white color, much finer-grained texture, entire absence of biotite, and decreased muscovite, the aplite and granite are similar. There are small aggregates of tourmaline throughout the entire mass of granite, in centers of white areas of quartz and feldspar, from a fraction of an inch to several inches in diameter, sharply separated from the granite. These areas are interlocking quartzes and feldspar, totally similar to the granite feldspars; the tourmaline is thought to have been derived by fumarolic action from the feldspars.

(P. 186) "In the Stone Mountain pegmatites the dark minerals, mica, tourmaline, and garnet, are frequently concentrated along the central axis of the dike or vein, rather than distributed through the light-colored quartz-feldspar portions."

(P. 193) "While no distinct evidence bearing on the contemporaneous origin of the tourmaline aggregates in the granite with those of the pegmatite and the tourmaline veinlets, it seems reasonable to assume such contemporaneity.

"The very nature of the areas oppose the hypothesis of direct secretion out of the eruptive granite magma. On the other hand, the characteristic mode of occurrence and intimate relationship to certain other mineral species present, as shown both macroscopically and microscopically, make it reasonably certain that the tourmaline areas have resulted from fumaroles highly charged with boric acid acting on the feldspars and mica."

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[28] On the Occurrence of Aplite, Pegmatite, and Tourmaline Bunches in the Stone Mountain Granite of Georgia, *Journal of Geology*, vol. x., pp. 186 to 193 (1902).

A. C. Spencer.[29] On pegmatitic structure at Grand Encampment, Wyoming.

". . . aplite . . . is here used for white, fine-grained rocks which are composed principally of quartz and oligoclase feldspar. Pegmatite is used for related rocks which are more coarsely crystalline than the aplite and of pink or reddish color. The feldspar of the pegmatites is usually orthoclase or microcline."

"The geologic relations of the aplite have not been completely determined, but bodies of the rock composed of feldspar and quartz and having the form of dikes were found to pass by gradation into quartz-veins, a fact which suggests that they may not be true igneous intrusions in the same sense as the gabbro rocks, but rather that they have been formed through aqueo-igneous activity, an origin to which many pegmatites have been assigned.

"The coarse pegmatites. . . . Like the aplites, they are found to grade into quartz-veins."

Small amounts of gold have been found in the quartz-veins and secondary copper in crushed pegmatite.

J. E. Spurr,[30] on the Silver Peak pegmatites. While it is usually impossible to do justice to an author through extracts, it is very much so in this case, as they are from a compendious monograph bearing directly on the auriferous quartz phase of pegmatitic differentiation.

On the subject of two periods of crystallization:

(P. 103) "The best crystallized muscovite occurs abundantly in cavities in granites and in pegmatites, associated with minerals like tourmaline, which is the result of the action of another mineralizer—boron."

(P. 105) Microcline almost always belongs to the second generation of crystallization, and zircon and pyrite always so.

C. W. Brögger is cited as placing pyrite and other sulphides in pegmatite dike-veins among the minerals formed at the second period of consolidation, when the action of water and other mineralizers was more potent in forming minerals than during the first period of consolidation, which was that of ordinary magmatic solidification; also, that while zircon is formed during the first period it also occurs among the minerals of the second period, and was probably formed by the action of mineralizers, presumably fluorine.

[29] Copper-Deposits of the Encampment District, Wyoming, *Professional Paper* No. 25, *U. S. Geological Survey*, p. 41 (1904).

[30] Ore Deposits of the Silver Peak Quadrangle, Nevada, *Professional Paper* No. 55, *U. S. Geological Survey* (1905).

A. La Croix describes, in an alkali granite from Madagascar (frequently pegmatitic), allotriomorphic or idiomorphic zircon inclosed in the quartz, sometimes in the feldspar. He regards this zircon as later than all the minerals except quartz. It is distributed in the granite and not localized in veins, and regarded as the product of emanations contemporaneous with the final consolidation of the rock.

(P. 107) Partial alteration of the feldspar into sericite occurred when the magma was partially consolidated, before deposition of the remainder of the secondary minerals.

(P. 112) "The magma was a viscous fluid, less viscous than a normal granitic magma, but still capable of the rôle of intrusion. From this magma crystallized, besides some of the ordinary accessory granitic minerals, principally feldspar and quartz, the consolidation of the feldspar in general preceding that of the quartz. The proof that the magma penetrated the sedimentary rock mass in every pore, and that many of the larger intrusive lenses are of accumulated material which was intruded along small channels now often difficult to find, together with the relatively slight amount of fracturing to which the older crystals have been subjected, indicates that the crystallization was all accomplished subsequent to the injection."

Dr. J. Lehmann found in Saxony in some pegmatite dikes, orthoclase usually intergrown with albite in form of perthite, and also covered with thick plates of albite. The albite had remained in solution till about the end of the formation of orthoclase.

C. W. Brögger "concludes that some albite forms in the pegmatitic dike-veins at a later period than the potash-feldspars, being one of the products of the second period of consolidation, when the chief factor in mineral formation is the influence of the 'mineralizers' residual from the previously consolidated portion of the magma. In part this later albite has originated by replacement of earlier orthoclase, showing that the residual solutions had grown sodic."

(P. 129) Under the heading Development of the Theory of Metalliferous Veins of Magmatic Quartz, Mr. Spurr briefly traces the theories of pegmatite formation through a series of authors from 1823 to 1905. With much further condensation the views are as follows:

Fissure dikes, Charpentier, 1823.

Dike-like segregations, contemporaneous with inclosing rocks, Keilhau in Norway, 1838; Hausmann; G. Kreischer in 1869; G. Woitschach in Germany; Kalkowski; and Teall in England.

Segregation veins from granitic juice during crystallization of the magma, Scheerer, 1846.

Lateral segregation veins, T. S. Hunt in Canada, 1863; and H. Credner in Saxony, 1875.

Aqueo-igneous fusion, ranging from jelly-like masses to attenuated solutions, and the results from granite to quartz, Dr. J. Lehmann in Saxony, 1884.

Aqueo-igneous dikes, injected in colloidal state, A. W. Howitt, quartz-veins in Victoria, Australia, 1887.

Intrusive siliceous magmas form pegmatites, and by a series of gradations, differentiations in the same process of magmatic segregations, attenuated solutions may be reached, forming quartz-veins, W. C. Brögger in Norway, 1890.

And about the same opinion as the last, A. C. Lane, 1894.

Normal pegmatites are granitic intrusions, and quartz-veins of the same area are formed by lateral secretion, G. H. Williams, 1895.

"In some cases igneous injection, in some cases aqueo-igneous action, and in other cases pure water cementation, and in still others combinations of two or all of these processes." C. R. Van Hise, 1896 and 1904.

Intrusion of differentiated siliceous magmas aided by water from the wall-rocks, Crosby and Fuller, in New Hampshire, 1897.

Transition from quartz-veins carrying pyrite, argentiferous galena, and gold to feldspar rocks, J. E. Spurr, 1898.

Magmatic differentiation *in situ*, from granitic magmas, F. D. Adams, Ontario granite-veins, 1898.

From pure quartz to pegmatite, Otto Nordenskjöld in the Klondike, 1899; J. F. Kemp, Long Island Sound, 1901; and J. E. Spurr and H. W. Turner at Silver Peak, Nevada.

Tourmaline pegmatite from siliceous differentiation of the magma and tourmaline quartz-veins from further separation into attenuated solutions, G. A. Waller and E. G. Hogg in Tasmania, 1903.

Recognized transitions from granite to quartz-veins, Iddings, Cross, Pirsson, and Washington, 1903.

Gradation from aplite dikes into quartz-veins, A. C. Lawson in California, 1904.

Transition of pegmatite to quartz-veins, J. E. Spurr and G.

H. Garrey in Colorado, and E. C. Andrews in New South Wales; both 1905.

Finally, Mr. Spurr's own views:

(P. 138) "Are very close to those held by Scheerer, Lehmann, Howitt, and Crosby and Fuller."

T. L. Watson,[31] describing the Virginia granites:

(P. 526) ". . . pegmatite, coarse crystallizations of quartz and feldspar with subordinate mica, in dike-like form, abundantly penetrate the finer granites and associated crystalline rocks over much of the Piedmont region."

(P. 536) "They are of granitic mineralogy, without the occurrence of unusual or rare minerals noted in them, and they cut alike the granites and the gneisses.

"They consist of coarse aggregates of feldspar and quartz, with more or less black biotite and a little muscovite. In the Fredericksburg quarries . . . massive granular magnetite and large and small perfect red crystals of garnet are not infrequent constituents."

(P. 538) "Where observed, the pegmatites are sharply defined from the inclosing rock; parallel banding to the walls does not occur; . . . and all of them are entirely massive, without any evidence of pressure metamorphism shown in them."

The following analytical suggestions about crystallization are from leaders of thought on the subject:

C. R. Van Hise,[32] on coarse crystallization in the general mass of the Black Hills granite.

As the granites have been so thoroughly described by Newton and Caswell, not wishing to reiterate he is quite brief:

(P. 230) "They are in the main coarse-grained muscovite-granites, the only important minerals being muscovite, quartz, and feldspar, the latter including orthoclase, microcline, and plagioclase. These granites are sometimes so coarse as to give muscovite approaching that of a merchantable character. These coarse phases are by no means universal; and they pass into rocks which have all the characteristics of muscovite-biotite-granites of the ordinary type."

A. C. Lawson,[33] on the structure of dikes of Rainy Lake region, Canada.

In these dikes, one 150 ft. wide showed feldspars in the center from 4 to 40 times as large as those in the porphyritic zone, 4 ft. from the contact. Generally, the dikes had ophitic struc-

[31] Lithological Characters of the Virginia Granites, *Bulletin of the Geological Society of America*, vol. xvii., pp. 523 to 540 (1906).

[32] Pre-Cambrian Rocks of the Black Hills, *Bulletin of the Geological Society of America*, vol. i., pp. 203 to 244 (1889).

[33] Petrographical Differentiation of Certain Dykes of the Rainy Lake Region, *American Geologist*, vol. vii., pp. 153 to 164 (1891).

ture intermediate between the porphyritic zone and the granular zone of the center. In the large dike no quartz was observable at the side, some grains were seen at the 4-ft. mark, at 15 ft. they are more abundant, while in the middle it is a most conspicuous ingredient. In a 65-ft. dike, in the ophitic and granular zone—that is, the central half of the dike—the quartz has pegmatitic intergrowth with plagioclase; this dike is of andesitic type, containing appreciable augite and hornblende; this pegmatitic structure also occurred in other dikes with plenty of augite. Although the macroscopic development of quartz was so noticeable in the central half of the dikes, analysis only gave a difference of, say, 2 per cent., from 49 to 51 per cent.; however, in the two largest dikes, 150 ft. and 120 ft. wide, the difference between contact and centers was 10 and 5 per cent., from 47.8 to 57.5 and 52.5 per cent.; the other constituents about balanced. During solidification of the dike the water was driven from the sides towards the center.

A. C. Lawson,[34] describing diabase dikes of the Rainy Lake region, Canada:

(P. 209) "Micropegmatitic quartz is abundant. It is often intimately intergrown with the feldspar, and as the latter is much decomposed, would seem to replace it as a partial pseudomorph, but apatite needles of the same aspect as those which occur as inclusions in feldspar, augite, and quartz, are often seen to be inclosed partly in a feldspar and partly in a quartz grain. The primary origin of the quartz in spite of its pegmatitic character, is however, not beyond doubt."

J. P. Iddings,[35] discussing the liquefaction and crystallization of magmas "which have been found to have diverse laws," and the influence of water-vapor, says:

J. W. Judd, following up Dr. Guthrie's experiments, found that dry nitre melted at 320° C. with 29.07 per cent. of water at 97.6° C.

(P. 27) "Inversely, some substances may exist as fluids at temperatures considerably below their ordinary point of solidification by being combined with water; there is a point, however, at which solidification sets in. Mr. J. J. Harris Teall, who has been studying some of Dr. Guthrie's eutectic compounds, finds that upon solidification they separate into their component parts, which interpenetrate one another like quartz and feldspar in granophyre or micropegmatite."

[34] Notes on Some Diabase Dykes of the Rainy Lake Region, *American Geologist*, vol. i., pp. 199 to 211 (1888).

[35] A Group of Volcanic Rocks from the Tewan Mountains, New Mexico, etc., *Bulletin* No. 66, *U. S. Geological Survey* (1890).

(P. 26) "Moreover, if we consider rock magmas as saturated solutions of silicate salts, as Lagorio has done in the paper already alluded to, we may apply to them the law which Sorby deduced for aqueous solutions of salts, namely, that the solubility of those salts, which, like the silicates, expand upon solution and condense upon crystallization, is decreased by increasing pressure. In other words, in such solutions an increase of pressure would tend to crystallize the salts from solution. Hence in a molten rock magma an increase of pressure alone would tend to induce the crystallization of certain silicate minerals from the magma, or might lead to the crystallization of the whole magma."

The descriptions of the pegmatites waver round the same points, and, as G. H. Williams put it, the modes of formation probably differed too, so that each of the modern observers is nearly or quite right. The prominent features in the discussion are, the dependence of the mass of the pegmatites on igneous intrusion, or more properly aqueo-igneous, as applied to the influence of water in conjunction with heat in causing the liquidity of granitic magmas; the modification of this fusion in the case of pegmatites by yet more water or aqueous vapors, the additional water having increased with the quartz contents. Next in importance is the occurrence of accessory minerals, spodumene, beryl, tantalite, phosphates, tourmaline, lepidolite, columbite, cassiterite, garnet, ilmenite, zircon, all of which have been considered closely associated with pneumatolytic action, and most of them classed as mineralizers from the hydrofluoric, boracic, and other acids entering into their composition. For instance:

Review by T. A. Jaggar, Jr.,[36] of the experiments by J. Morozewicz (Warsaw) on synthesis of minerals and volcanic rocks. These experiments consisted of melting suitable compounds in crucibles in a corner of a glass-furnace at a temperature of from 500 to 1,600° C. and examination of the products. Among those experiments:

(P. 306) "Rhyolite and trachyte magmas, with the Al_2O_3 percentage varying from 6 to 20, were fused in large masses under varying conditions of cooling, and for periods of a fortnight or more, solidifying invariably as structureless glass. . . . Finally success was obtained by adding 1 per cent. of tungstic acid to a rhyolite mixture." . . . [There were found under the microscope] ". . . myriads of bipyramidal quartz microlites, . . . hexagonal plates of biotite . . . transparent prisms . . . believed to be sanadine. . . . There had thus been reproduced by 'dry fusion,' with the aid of tungstic acid, an association of the essential minerals of granite—quartz, mica and acid

[36] *Journal of Geology*, vol. vii., pp. 300 to 313 (1899).

feldspar. . . . Modern petrographers have not ascribed any 'mystical' power to the compounds of tungsten, zirconium, boron, fluorine, etc., but have observed that these elements are minor but invariable accompaniments of the crystallization of coarse acid pegmatites . . . their influence, whether chemical or physical, cannot be denied."

Morozewicz had rather scoffed at the acid having any mystical power.

It has often been explained that exudations from magmas, besides dikes, consist at first of vapors and gases at high temperatures, as seen in fumaroles, which often carry fluorine, and are sometimes as much as 500° C. at the surface. It is apropos that Brauns has said that a mica can be formed if its elements are melted with a fluoride below 800° C.; above that temperature they are unstable, excepting biotite. The vapors are followed by hot waters, which may originate from them by condensation, either from cooling of the parent magma in depth or in passage of the vapors towards the surface, the seat of origin being sometimes many thousands of feet below it. G. F. Becker thinks some of the Southern Appalachian ore-deposits are now exposed by erosion from 15,000 to 20,000 ft. below their original apex, and other deep-seated deposits are known to be 6,000 ft. below the old surface. There is no telling how much further they extend.

While the minerals deposited by such vaporous action are on the whole different from those due to solfataric waters, yet the two series overlap. Tin and apatite veins, and their respective accompanying minerals, are considered representative of the former. As the two types merge into one another (tin is an especially well-known product of ordinary solfatarism), in a district like Cripple Creek, where the veins contain fluorine, a typical representative of pneumatolytic action, and little quartz, speculation could be rife as to what might be found in the veins at great depth. In the pneumatolytic zone, tin, for instance, but it is nipped in the bud by the total absence of this mineral in the superficial areas opened.

As ordinary gold-, silver-, and lead-quartz-veins merge into tin and apatite pneumatolytic veins, and both of them into contact deposits, so from the above descriptions of the pegmatites of the eastern United States, I would imagine them to be: eruptive dikes, pneumatolytic veins, and quartz-veins pass-

ing (?) into one another. To be succinct, that the major part of the pegmatites are only ordinarily coarse-grained siliceous dikes, as Crosby and Fuller have outlined, cooling slowly, influenced by a comparatively small amount of accompanying vaporous mineralizers, and that after extravasation and before cooling, pneumatolytic vapors had passed through various channels along the dike, creating the coarse crystallization by keeping certain lengths and breadths of the dike liquid for a sufficient time, allowing further differentiation or formation of eutectic compounds, and that the same pneumatolytic action introduced the rarer minerals.

That after this took place, and after consolidation of the dike, there occurred the next stage of solfatarism, and the introduction in the fissured or brecciated dikes, or in other fissures or lines of least resistance in the adjacent country, of quartz as a residue from attenuated waters.

It may be said that these three phenomena are all phases of the same process of magmatic differentiation; so it may be granted is the diabase dike on the foot-wall of the Comstock and the lode itself, but they have not been classified together.

C. R. Van Hise[37] has qualified veins and dikes:

". . . the first representing crystallizations from water-solutions; the second, crystallization from magma."

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[37] Some Principles Controlling the Deposition of Ores, *Trans.*, xxxi., 288 (1901).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Volcanic Waters.

BY JOHN B. HASTINGS, DENVER, COLO.

(New York Meeting, February, 1908.)

THE origin of the watery vapors of vulcanism has always been an object of interest and speculation to the seismologist, and as theories of the genetic origin of ore-deposits have of late years been pretty well narrowed down to the expiring forces of plutonic action, the same question has had a lively interest for mining engineers and geologists, as is well shown by the discussions of the subject in our *Transactions*. The important part taken by volcanic emanations in the origin of pegmatites and quartz-veins, described in my paper, Origin of Pegmatite,[1] and their latent power to concentrate into useful deposits such scattered gold as occurs in the Hartsel granite, make a discussion of their derivation but a natural third and final step.

It is conceded that enormous amounts of vapor accompany vulcanism, though perhaps we are apt to forget that steam has 1,700 times the volume of water, besides which the column seen over Vesuvius and other volcanoes is greatly mixed with air; the immensity of such volumes compared with solids and liquids is shown by the experiment of Gautier, who, by heating dessicated granite to 100° C., evolved from it gases 20 times, and steam 90 times, its own volume. Dana appraised the average amount of water left in ordinary rocks as 2.5 per cent.

T. M. Read estimated that the Mississippi river carries to the sea annually 150,000,000 tons of rock material. If these Mississippi sediments, as deposited, contained 20 per cent. of water, it would be 600,000,000 cu. ft., or 4,500,000,000 American gallons, annually. Allowing the vapor suspended over a volcanic cone to be mixed with 80 per cent. of air, this amount of water converted into steam would replenish anew, every 9 min., a column 15,000 ft. high, 2,000 ft. in diameter at the base, and 10,000 ft. at the top. Read's estimate is only half of the amount given in a more recent and probably correct one.[2]

[1] P. 319 of this *Bulletin*. [2] Chamberlin & Salisbury, *Geology*, 2d ed., vol. i., p. 106.

In the present paper, however, it is not intended to dispute estimates of the vapors accompanying vulcanism, or what part of it springs from primeval hydrogen and oxygen locked within the earth's interior, or from vadose or oceanic waters. It is simply my purpose to ask whether any of the water buried deeply with oceanic sediments can make its way to the conduits of molten material. An immense amount of water is buried with sediments, and it probably stays there until removed by the rise of the isogeotherms of internal heat—either a gentle rise, or a comparatively sudden one, accompanying the movement. Our experience in cyaniding teaches us that water will stay in interstitial spaces until displaced by another substance or exhausted into a vacuum. Hence, the spaces left in compressed sediments will be full of water, unless the isogeotherms rise as the sediments are laid down and expel it. The gentle action of heat is aided by the expansion and loss of viscosity of warmed water; the latter quality is said to be about one-fifth at 100° C. of what it is at 0° C.

Though enormous pressures can be figured on every square inch of buried sediments, the evidence of compression in them, except where there has been movement, is not great. The pulpy matter of rotted sigillaria, etc., has been crushed to perhaps 1 per cent. of the original volume, and converted into bituminous coal; but even this coal is not a very dense material to preserve its form over areas of many square miles when buried under thousands of feet of rock subsequent to the Carboniferous. It takes extreme pressure and heat to make anthracite.

G. H. Eldridge[3] describes early Tertiary lignite of Cook Inlet, Alaska, many of the beds being from 4 to 6 ft. thick, as:

> ". . . hardly more than a compressed mass of carbonized wood, it being possible to pull up from the back of a seam slivers from a few inches to 3 feet in length. Stumps 1 foot to 2 feet in diameter are common . . . Indeed, in some of the local bogs resting upon the coal measures there are stems and other woody tissues that closely approximate some of the less altered varieties of the lignitic material."

I do not know how thick the superincumbent beds over the coal were originally. W. H. Dall,[4] who studied the region,

[3] A Reconnaisance in the Sushitna Basin and Adjacent Territory, Alaska, in 1898, *20th Annual Report, U. S. Geological Survey,* pt. vii., pp. 7 to 29 (1898–99).

[4] Report on Coal and Lignite of Alaska, *17th Annual Report, U. S. Geological Survey,* pt. i., pp. 771 to 875 (1895–96).

says that at this particular point these Tertiary Kenai coal-beds are conformably overlain by Miocene marine beds, but the subsidence which enabled it was "probably moderate in vertical range."

As to the rise of the internal isogeotherms from normal conductivity or pressure, there is little light, except theoretical. The continents show increased temperature with depth, but they are areas of considerable movement—elevation—which in itself would be accompanied with heat, and what remains may be, in part, residual. The same might be said of the ocean bottoms, substituting a movement of depression.

If the heat-conductivity in the earth be judged by its radiation it is very slight. It has been described as small, but still measurable. The abyssal ocean waters are just above freezing-point. This low temperature has been thought to be due to rapid extraction of the earth's heat from the oceanic beds by conductivity because of their greater density than the continents, for instance, and the rapidity with which the waters absorb the heat and quickly distribute it through convection. Again, it has been ascribed to the immense polar currents moving slowly southward along the bottom. It is hard to find any warmth in the ocean except that due to the rays of the sun. Chamberlin and Salisbury,[5] citing P. G. Tait's *Heat* and A. Daniell's *Physics*, assert that these authors respectively place the earth's loss of heat in 100,000,000 years at 18° F. and 81° F. for the whole body of the planet.

Do the sediments as deposited contain much water, and do interstitial spaces survive compression of the beds?

J. D. Dana thought that

"sedimentary beds contain their maximum of moisture when laid down; and with this, though situated at the bottom of a trough, they have still laid quietly."

Not much has been said of late by geologists about water carried down in sedimentary beds as they are deposited. Sterry Hunt and others referred to it, and thought that some eruptive rocks were formed from saturated sedimentaries.

Perhaps the only emphatic recent article bearing on the subject is by Prof. King,[6] and not only treats of the amount of water

[5] Chamberlin and Salisbury, *Geology*, 2d ed., p. 572.

[6] F. H. King, Principles and Conditions of the Movements of Ground Water, *U. S. Geological Survey*, *19th Annual Report*, pt. ii., pp. 59 to 294 (1897–98).

the sediments might once have held, but presents a study of them after elevation, and shows their storage-capacity up to the present time. The following passages are quoted from it:

(P. 69) ". . . sandstones lying below drainage outlets may contain as high as 38 per cent. of their volume of water. . . The Dakota sandstone, for example, stretching from the foothills of the Rocky Mountains eastward beneath the plains of the two Dakotas, Nebraska, and Kansas, apparently in one nearly or quite continuous sheet, may be likened to a submerged inland sea or lake, for wherever this formation lies beneath the zone of saturation it carries within itself from 15 to 38 feet of water on the level for every 100 feet in thickness of the sandstone itself, and from it water may be drawn wherever it lies close enough to the surface to be reached by wells. The Potsdam sandstone is a formation of much wider distribution than the Dakota, and in southern Minnesota and Wisconsin and in Illinois and Iowa it has a measured thickness of 500 to 1,000 feet, all lying beneath the surface of saturation, so that in this great bed there has been stored away a quantity of water equal to a sheet not less than 10 to 38 feet in depth for each 100 feet in thickness, and 500 feet of this water-bearing rock may store the equivalent of an inland submerged sea having a mean depth of 50 to 190 feet of water."

Ordinary clay with sand held 25 per cent. of water, and very fine sand 17 per cent. Marble held very little, 0.25 per cent., or a column of 5,000 ft. held 30 ft. of water.

(P. 77) "We know that when sediments are laid down on the borders of the ocean or over the bottom of inland seas, gulfs, or bays there becomes locked up with them large volumes of water, quantities varying from 25 to 50 per cent. of the volume of the sediment, according as the pore space in the sediment is large or small.

"It will be seen in another part of this paper that the pore space of loose sands, when packed as closely as tamping and jarring will secure, amounts to from 30 to 38 per cent., while the pore space of clays and finer soils runs up as high as 45 and even above 50 per cent., and there is no reason to suppose that the sediments, whether they be sands, clays, or limestone débris, will be laid down with greater compactness than we have been able to secure in our experimental work.

"Seelheim[7] has shown that when an emulsion of fine clay and water is allowed to stand quietly for some time under conditions where no jarring can take place the clay subsides, assuming a stratified condition, but containing a large amount of water. He found where no jarring took place that the upper layers contained more water than the lower ones, the proportion being 1 volume of clay to 3.84 volumes of water in the upper strata and 1 volume of clay to 1.78 volumes of water in the lower strata. That is to say, in the loosest settling 79.34 per cent. of the volume of the sediment was water and in the closer packing there was still 64.03 per cent. of pore space.

"Where the settling was allowed to take place under frequent jarrings Seelheim secured a uniform texture throughout and greater compactness, but there was

[7] Methoden zur Bestimmung der Durchlässigkeit des Bodens, *Zeitschrift für analytische Chemie*, vol. xix., p. 387.

still a pore space of 54.54 per cent. He further showed that there was no sensible reduction of pore space when the sedimentation was caused to take place under a pressure of 102 feet of water instead of a few feet. Further than this, there is no reason to suppose that the pore space of sediments laid down under water will not be filled very largely with the water in which they are deposited."

Experiments with sediments laid down in a cylinder showed that the water flowed downward or laterally through the sediments and up through a rubber tube discharging 6 in. above the top of the column of water and sediments; it was not denied that some water, as the sediments were deposited, may have come up vertically through them, but the lateral and downward outlet seemed the line of least resistance.

(P. 80) "We have no quantitative measure of the amount of compression which, under the conditions of natural sedimentation, takes place where beds of shale and limestone are formed. . . . .

" . . . Such consolidation of sediments and displacement of water as may have taken place by the ordinary processes of sedimentation unaided by other agencies must still have left large volumes of inclosed water to be deeply buried in districts like the Appalachian region, where, during Palæozoic time, if the estimates of Dana are accepted, an aggregate subsidence and sedimentation of 36,000 feet must have taken place."

When these materials were laid down the pore-space was about 33 per cent., or 12,000 ft. of water. But these rocks have since been greatly consolidated, highly metamorphosed and crystallized, perhaps making the pore-space much less than 33 per cent., so that if they were now full of water a very large amount would have been displaced in the past. The same thing has occurred in the interior region of our continent.

(P. 81) "These large volumes of water which have been carried beneath the earth's crust as a phase of the process of sedimentation must in part have reappeared at the surface in one place or in another, and there must of necessity be an underflow of the entrapped sedimentary waters from beneath the ocean toward the land." [Such subsidence produces increased temperature of the material, and resultant flow of water.—J. B. H.] "Poiseuille found that water at a temperature of 45° C. flowed 2.5 times as fast under otherwise like conditions as water at 5° C."

G. F. Becker[8] says quartz weighs 165 lb. per cu. ft., and resultant sand well shaken down 120 lb. per cu. ft.; therefore, the sand contains 27.3 per cent. of interstitial space. This sand

[8] Geology of the Quicksilver Deposits of the Pacific Slope, *Monograph No.* 13, *U. S. Geological Survey*, p. 399 (1888).

compared very well with the natural sand-beds and sandstones of the California quicksilver-mines.

"Were the sand composed of spherical grains all of the same size and as closely packed as possible, so that every sphere was in contact with twelve others, the mass would contain 26 per cent. of interstitial space."

Indurated sandstone used for paving the streets contains 8 per cent. of interstitial space.

W. O. Crosby,[9] in discussing the coloration of the sandstones near Colorado Springs, inadvertently suggests limitation of inclosing water:

"In deeper and more quiet water offshore, where the overlying reddish sandstone must have been deposited, enough red clay would also naturally have been deposited to fill the interstices between the grains and give the sandstone a ruddy tint."

On this principle, it is somewhere stated that conglomerates may contain as low as 7 per cent. of water.

The results of a series of experiments on the porosity of rocks, made both by himself in Canada and by others in England and France, are tabulated by Sterry Hunt.[10]

The only reference I can find as to what actually became of the originally inclosed sedimentary waters, except those consumed in chemical hydration, is the mention of saline springs in eastern United States and Canada, with analyses of them, by Sterry Hunt, in his essays.

Do sediments subside until they are an immense depth below the ocean bottoms?

This is the general opinion of geologists.

J. W. Dawson[11] wrote that 10,000 to 20,000 ft. of sediments in Nova Scotia and eastern United States were laid down in shallow seas—that is, the bottom of the seas subsided as they were deposited.

In the Alps the sediments accumulated between the Permian and late Cretaceous periods are thought to exceed 50,000 ft., all accumulated in shallow water. Dana says:[12]

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[9] Archean-Cambrian Contact Near Manitou, Colorado, *Bulletin of the Geological Society of America*, vol. x., p. 164 (1898).

[10] *Chemical and Geological Essays*, 2d ed., p. 165 (1878).

[11] *Some Salient Points in the Science of the Earth.*

[12] *Manual of Geology*, 3d ed., p. 391.

"Consequently, when these last layers of the Palæozoic in the Appalachian regions were at the ocean's level, the Potsdam beds—though once also at the surface—were about *seven* miles below; for this is the thickness of the strata that intervene; seven miles of subsidence had, therefore, taken place in that region during the progress of the Palæozoic ages."

Clarence King judged that the subsidence in the Rockies amounted to 60,000 ft.

S. F. Emmons[13] thought that from early Cambrian to early Carboniferous the great accumulation of beds in the longitude of the Wasatch mountains amounted to from 15,000 to 20,000 ft., not strictly without movement of elevation and depression, but without great disturbance.

Bailey Willis says:[14]

"In the Appalachian trough opportunity for maximum sedimentation during the Paleozoic was afforded by the profound subsidence of an area in New York, Pennsylvania, Virginia, and Ohio. At Mauch Chunk the total thickness is approximately 30,000 feet."

R. T. Hill,[15] describing the Beaumont oil-fields, refers to 25,000 ft. of marine sediments, from Cambrian to recent, minus the Devonian, and says they are—

"tilted steeply in the mountainous areas, and are nearly horizontal in the plains."

(P. 400) "Of the 22,000 ft. of sedimentaries in the Texas section, all but less than 2,000 ft. are unconsolidated clays and sands."

These examples might be multiplied. Chamberlin and Salisbury, in their beautiful new *Geology*, give a touch of the other side of the question. They allow that subsidence has gone on in epicontinental (shallow bordering) and mediterranean (deep inland) seas, the inland sea of North America, for instance, and do not deny that it occurs elsewhere, but think that errors in computation may have been sometimes made. For instance, suppose sediments deposited conformably on the abyssal floor of an ocean, which slopes 2° until a depth of 4 miles is reached, whence the floor goes off flat, but the sediments keep on piling up conformably at 2° dip till they are built out 200 miles from

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[13] Geology of the Denver Basin in Colorado, *Monograph No. 27, U. S. Geological Survey*, p. 15 (1896).

[14] A Theory of Continental Structure Applied to North America, *Bulletin of the Geological Society of America*, vol. xviii., p. 399 (1906).

[15] The Beaumont Oil-Fields, etc., *Trans.*, xxxiii., 368 (1903).

shore. An observer at the shore end, taking the angle of dip of the first bed laid down, and protracting it for the 200 miles, which on this dip would take it away below the ocean bottom, and then calculating the distance at right angles to the dip from the bottom of this first sediment to the top of the last one laid down, would get 7 miles, instead of 4, the real depth of the ocean and true thickness of the sediments. It is certainly plausible that protracting a dip for 200 miles might lead to error. If it were protracted 5 miles the discrepancy would be 0.15 mile. Another citation is given of a lake 100 miles wide, with sides sloping at 3° till a depth of 1,000 ft. was reached, whence it remained flat. The sediments were then laid down conformably at an angle of 3°. The observer takes the angle of dip at the shore and protracts it at 3° for 50 miles, getting so far below the bottom of the 1,000-ft. lake that his computation at right angles to the 3° dip, at end of the 50 miles, gives a depth of 13,800 ft., intead of 1,000 ft. These layers of sediment, diagonal to the depth of the lake, would butt against its bottom in about 3 miles—that is, if any of the beds were followed from the outcrop down the 3° dip for that distance, they would be found ending in a truncated edge against the lake bottom, so that their horizontal length would be little more than the supposed thickness, whereas the Appalachian relations, as computed, are in horizontal extent 20 times or more their thickness.

Are the continental shores lines of weakness, so that there is a possibility of the inclosed waters of the sediments passing from them into the land areas?

While there are certain parts of the present continents and also oceanic depths which are thought to have existed since the dawn of geologic history, it is well known that almost all of the inner area of North America has been occupied by a mediterranean, so that tremendous thicknesses of sediments have been laid down, in Arizona, Utah, Idaho, and British Columbia; that the ancient sea of Tethys stretched from Spain to the eastern coast of Asia; that the Arctic was once much larger than now, and also that the southern continents, Africa, Australia, and South America, were apparently closely connected. These facts have been worked out with much research by such men as Dawson, Dana, etc., on our own shores, and by others elsewhere.

The facts have been lately collated by B. Willis, who says, in effect,[16] that uplands of erosion and lowlands of aggradation are commonly joined by a monoclinal flexure, or a normal fault. Great horizontal movements are shown in the schistose structure of once deep-seated rocks. These movements crowded the continental elements together, as is evidenced by the shortening of the Appalachian sediments from their original horizontal breadth; according to the Rogerses, from 168 miles to 60 miles. Lately, however, the narrowing has been put at 35 to 45 miles. Much may depend, perhaps, on the locality of the section observed.

That oceanic areas might be denser than continental, probably dawned early in a number of minds and was mentioned by some, but Captain E. P. Dutton was the first to formulate with emphasis the theory of "isostacy," which predicates that the sectors of the oceans and continents are in equilibrium, the depressions of the one and elevations of the other equalizing the specific gravity of the two.

Willis calls the oceans and continents positive and negative elements, and specifies the line of contact between them as a zone of weakness, especially favorable for the development of intrusive and extrusive bodies.

It may be interesting for a moment to glance at B. K. Emerson's[17] statement of the theory of a tetrahedral earth as postulated by its originator W. L. Green, a Honolulu merchant:

> "The sphere, of all solids, contains the greatest volume under a given surface, the tetrahedron the least volume under the same surface. The solid spherical crust of the earth, then, collapsing upon its plastic interior, would tend toward the tetrahedral form as the one which would coördinate the greatest diminution of the interior with the least change of the surface."

The continents are shown to be situated more or less on the protuberances of the tetrahedron. Emerson says the tendency for the earth to take such a form may be allowed to exist and would be in evidence where not balanced by other forces.

However approached by geologic theory, I think it is most generally acknowledged that continental shores are broad lines of weakness. Furthermore, that the general arrangement of

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[16] The Mechanics of Appalachian Structure, *13th Annual Report, U. S. Geological Survey*, pt. ii., pp. 211 to 281 (1891-92).

[17] The Tetrahedral Earth and Zone of the Intercontinental Seas, *Bulletin of the Geological Society of America*, vol. xi., pp. 61 to 106 (1899).

volcanoes, as taught by Dana and others, is symmetrical with these lines. This does not preclude volcanic action far away from the coast. If the elevation of the continents is due to the thrust of the denser oceanic beds large distances may be insignificant. Neither does it preclude vulcanism under the ocean. In fact, J. W. Dawson has described the Atlantic as "almost an unbroken cake" and the Pacific as "cracked in many places, allowing the fluid matter to exude in volcanic ejections." Nor does it matter that there are quiescent areas, where under this law vulcanism might be expected to be active. Many have observed the marked feature of critical epochs in the world history, that there have been geological periods of slow subsidence and elevation without much vulcanism.

What is the depth of vulcanism?

This may be great indeed, but the depth of earthquake centrums, which we associate with movements in the earth's crust (faulting), originally considered as great (even from 30 to 55 miles by Mallet), has of late years been restricted to 5, 8 or 12 miles, which brings it not so much below the sedimental range.

Are the waters of vulcanism similar to those included in sediments?

Since it is not supposed that these waters are exclusively derived from the sediments, they may be greatly modified mixtures as we see them. Prestwich says:[18]

"Not only are almost all the elements of sea-water found in the gases and deposits of fumaroles, with the exception of the salts of magnesia which has become fixed in the lava, but sea-salt itself is often found in lava or is deposited on its surface."

The *Challenger* reports give the salts of sea-water as roughly: sodium chloride, 78; magnesium chloride, 11; magnesium sulphate, 5; calcium sulphate, 4; potassium sulphate, 2; calcium carbonate, 0.25; magnesium bromide, 0.25 per cent. The total quantity of salts is fairly uniform as 3.5 per cent. of the water. The salts vary; sometimes the bromides are more plentiful, and strontium, iodine, fluorine, glauconite, etc., are found.

Are oceanic sediments usually dehydrated before or during elevation, and which way is the water driven, upwards or laterally, and if laterally, seawards or landwards, and if landwards, is it likely to sometimes penetrate, and incorporate with, plutonic magmas, and at depths beyond any it is agreed vadose waters can reach?

[18] *Geology: Chemical, Physical and Stratigraphical*, vol. i., p. 213 (1886).

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Coal-Briquette Plant at Bankhead, Alberta, Canada.

BY EDWARD W. PARKER, WASHINGTON, D. C.

(New York Meeting, February, 1908.)

THIS plant was built in 1907 at the Bankhead mines to manufacture briquettes by the Zwoyer process under license from the Zwoyer Fuel Co., of New York, N. Y.

The building was constructed to contain two units, each of a capacity of 10 tons per hr.; one unit was installed at the time the building was constructed, and the second unit is now being built.

The coal used is an anthracite, which is more friable than that of Pennsylvania, and, as a consequence, a larger percentage of dust or waste is produced, which was formerly thrown upon the slack-pile as waste, but is now passed to the "dust-bin" in the breaker, from which it is conveyed to the briquette-plant.

An average analysis of the coal, published by Lewis Stockett and B. R. Warden,[1] is as follows:

	Per Cent.
Moisture,	0.50
Volatile,	8.00
Fixed carbon,	83.50
Ash,	8.00
Total,	100.00
Sulphur,	0.40 per cent.
Specific gravity,	1.40
Color of ash,	white
Heat value,	14,000 B.t.u.

The plant is run under two 12-hr. shifts, the force consisting of 1 superintendent for both shifts, 1 engineer for each shift, 1 briquetter for each shift, 1 helper for each shift, 1 laborer cleaning up for each shift. In the pitch-melting house 2 men on duty for one shift.

[1] *Journal of the Canadian Mining Institute*, vol. ix., p. 261 (1906).

The steam for the engine is furnished from a central boiler-plant, which also supplies steam for the breaker, the electric light and power-plant, machinery-shop, and boiler-shop.

During March, April, May, and half of June, in 1907, the plant was operated on part time, due to the reduction of the boiler-capacity on account of heavy scale being formed on the boiler-tubes and sheets, and to the miners' strike. About the middle of June an additional boiler was installed, and the water from a spring supplied by the melting snow was used, which enabled the briquette-plant to be operated continuously from Monday morning until Sunday morning. Any loss of time at present will be from failure to obtain cars for loading the briquettes. The output during six months of 1907 was: June, 4,882; July (459 hr.), 4,593; August (499 hr.), 7,054; September, (420 hr.), 5,432; October (570 hr.), 7,668; November (558 hr.), 8,147, the total for the year being 43,703 tons.

During October, notwithstanding the loss of 5 days of operation (4 days on account of car-shortage and 1 day occupied in installing a pitch-tank for the second unit), the production amounted to 7,668 tons in a total running-time of 570 hr., and in November the total output was 8,147 tons and the running-time 558 hr. The average run per hour in October was 13.45 tons, while in November it was 14.6 tons.

The latest information regarding the operations of the Bankhead plant was received about Jan. 1, 1908, to the effect that a second press had been shipped from New York early in December, and as soon as this press was in place, so that a sufficient output could be obtained, one division of the Canadian Pacific Railroad would burn nothing but briquettes on its locomotives. This indicates that the experiments up to the first of the year had been quite satisfactory, otherwise the railroad company would not have gone to the expense and trouble of drafting its locomotives to burn briquettes exclusively. When the additional unit is in operation, the plant will probably produce from 15,000 to 16,000 tons of briquettes per month.

Domestic consumers seem to be well pleased, and there is a large demand for briquettes, which sell for $4 per ton at the plant.

Fig. 1 is a general view of the Bankhead Mines buildings, including the briquette-plant at the right of the breaker. The

A, Slack-pile. B, Breaker. C, Briquette-plant. D, Boiler-plant. E, Electric-plant.

FIG. 1.—GENERAL VIEW OF THE BRIQUETTE-PLANT AT BANKHEAD, CANADA.

A, Cooling-house. B, Dust-bin. C, Dust-conveyor. D, Briquette-conveyor. E, Box-car loader. F, Breaker.

Fig. 2.—View of Breaker, Conveyors, Dust-Bin, and Cooling-House, at Bankhead, Canada.

A, Pitch-melting house. B, Dust-bins. C, Briquette-machinery house. D, Breaker. E, Cooling-house. F, Slack-pile.

FIG. 3.—VIEW OF BREAKER, BRIQUETTE-BUILDINGS, AND COOLING-HOUSE, BANKHEAD, CANADA.

A, Press. B, Elevator to press. C, Mixers. D, Working pitch-tank. E, Dust-bins.

FIG. 4.—INTERIOR OF BRIQUETTE-MACHINERY HOUSE, AT BANKHEAD, CANADA.

boiler-plant is located on the right between the briquette-plant and the electric light and power-plant. The slack-pile is shown on the low ground at the left of the breaker.

Figs. 2 and 3 show the relative location of the breaker and the briquette-plant, the latter consisting of a pitch-melting house, and the main building, which includes dust-bin, machinery-house, and cooling-house.

The pitch-melting house, about 23 by 47 ft. in area, is separated from the main building, and contains two melting-tanks, each 12 by 6 ft. and 8 ft. deep.

The dust-bin, 20 by 30 ft. and 24 ft. deep, is placed at the rear of the machinery-house. This house is 60 by 73 ft. in area, and contains the briquette-machinery, crusher, mixer of six units, pitch storage-tank, 12 by 6 by 8 ft., double cylinder engine, 14- by 20-in. stroke, two dust-elevators, and briquette-press. The cooling-house, 31 by 129 ft. in area, contains the cooling-table and machinery for driving the briquette-conveyor.

Fig. 4 is an interior view of the machinery-house, and shows the press at the left, back of which is the engine; the conveyor from No. 6 mixer to the press; the mixers in the center and back; the pitch storage-tank at the right; and bins forming the end of the building.

The dust from the operations of the breaker is conveyed to a dust-bin at one end of the breaker, from which it is taken by a scraper-conveyor to the dust-bin in the briquette-plant. The dust is removed from the bins and conveyed to the crusher by a drag-chain. It then passes through the crusher and is elevated to the mixers, where it is heated by means of the hot gases from the mixer-furnace, which enter the mixers through flues in their sides. The pitch is introduced by means of an atomizer while the dust is passing through the mixers. As soon as the mixture reaches the end of mixer No. 6, it is conveyed by an elevator to the press and briquetted. The briquettes are carried by a belt-conveyor to the distributor over the cooling-table, and are carried back and forth the length of the table seven and three-quarter times, finally being dropped into the briquette-conveyor, which carries them to the briquette-bins in the breaker-house. From these bins the briquettes are loaded by means of chutes into gondola cars, and by means of a Victor box-car loader into box-cars.

All of the material is handled by machinery, which gives a continuous operation from the time the dust leaves the breaker until it is returned to the breaker-house in the form of briquettes.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Mechanical Preparation of Ores in Sardinia.

BY ERMINIO FERRARIS, MONTEPONI, SARDINIA, ITALY.

(New York Meeting, February, 1908.)

I. Historical Review and Introduction.

THE development of the mining industry in Sardinia dates from the application of the mining law of 1859, which, following the example of the French mining law of 1810, declared prospecting to be free, and suppressed the liens which had previously attached the mine to surface ownership.

The first ore-dressing plants were installed by German engineers upon the classic models of the Harz and of Freiberg; but in 1880 Sardinia commenced to open a new path in that industry, utilizing the refuse from the mining of rich, selected minerals, of poor deposits, and of mixed ores.

The first experiments were attempts to adapt the existing apparatus to local conditions, but progress was rapid, as was demonstrated already in 1887 by the calamine-dressing-mill of Monteponi, which exhibited a large plant designed in accordance with the experience gained, and constructed entirely in the machine-shops of the country, after new models and designs.[1] This example was followed two years later by the Société Malfidano, with a large plant of the same sort, and with the reconstruction of the old-fashioned dressing-mill, built in 1880 by the Austro-Belgian Company. In 1900, almost all the mines of Sardinia had adopted the new designs, and the island contained 32 concentrating-works, employing 2,000 h.p. and 1,924 workmen. Since that time, there have been added a large dressing-mill for blende at Gennamari, and two for calamine, at San Giovanni and at Masua, while the establishments at other mines have been enlarged and perfected. For the treatment of intimately mixed ores, a large establishment has been built upon the new

[1] La Laveria calamine della Miniera di Monteponi (Sardegna). By Ing. Erminio Ferraris. *Annale degli Ingegneri e Architetti italiani.* Anno IV, Fascicolo IV, Roma, 1889.

principles at Rosas, which has solved the question of the utilization of these ores, previously neglected for lack of the means of separating them.

In considering the general case of mechanical preparation it is necessary, to distinguish the two following operations: (1) The concentration of valuable minerals contained in the total product, removing the barren portions as far as possible; and (2) the separation of valuable minerals from each other, and the further removal of barren matter intimately mixed with the useful minerals.

The work of concentration of the original crude product is performed by utilizing the difference in specific gravity between the useful and the barren minerals. The usual gangue minerals of the ores in Sardinia, dolomite, limestone, schist, clay, quartz, and diabase, which have a specific gravity not exceeding 3, are easily removed, leaving concentrates of galena, blende, smithsonite, calamine, etc., together with mixed miscellaneous products resulting from the presence of heavy minerals, such as barite, limonite, and pyrite.

Concentration is effected in two different operations: the classification of the material according to the size of the grains; and the separation of the classified grains according to their specific gravity.

II. Classification.

The two forms of classification are: (1) screening, which is used for grains generally larger than 2 mm., but can be used on 0.5-mm. grains; and (2) sorting by a current of water, which is used for grains smaller than 2 mm., fine sands and slimes.

1. *Screening.*

Until the end of 1894, screening was almost universally accomplished by the rotary trommel, but its defects, well known to all mining engineers, made a less cumbersome and more durable apparatus desirable. After many experiments, trommels were superseded with great advantage by vibratory screens, the idea being borrowed from the modern flour-mill. At the beginning of 1898, screening at the calamine-dressing-mill of Monteponi was completely transformed according to the new system of vibratory screens, and they were at once adopted by nearly all the mills of Sardinia and Tunis.

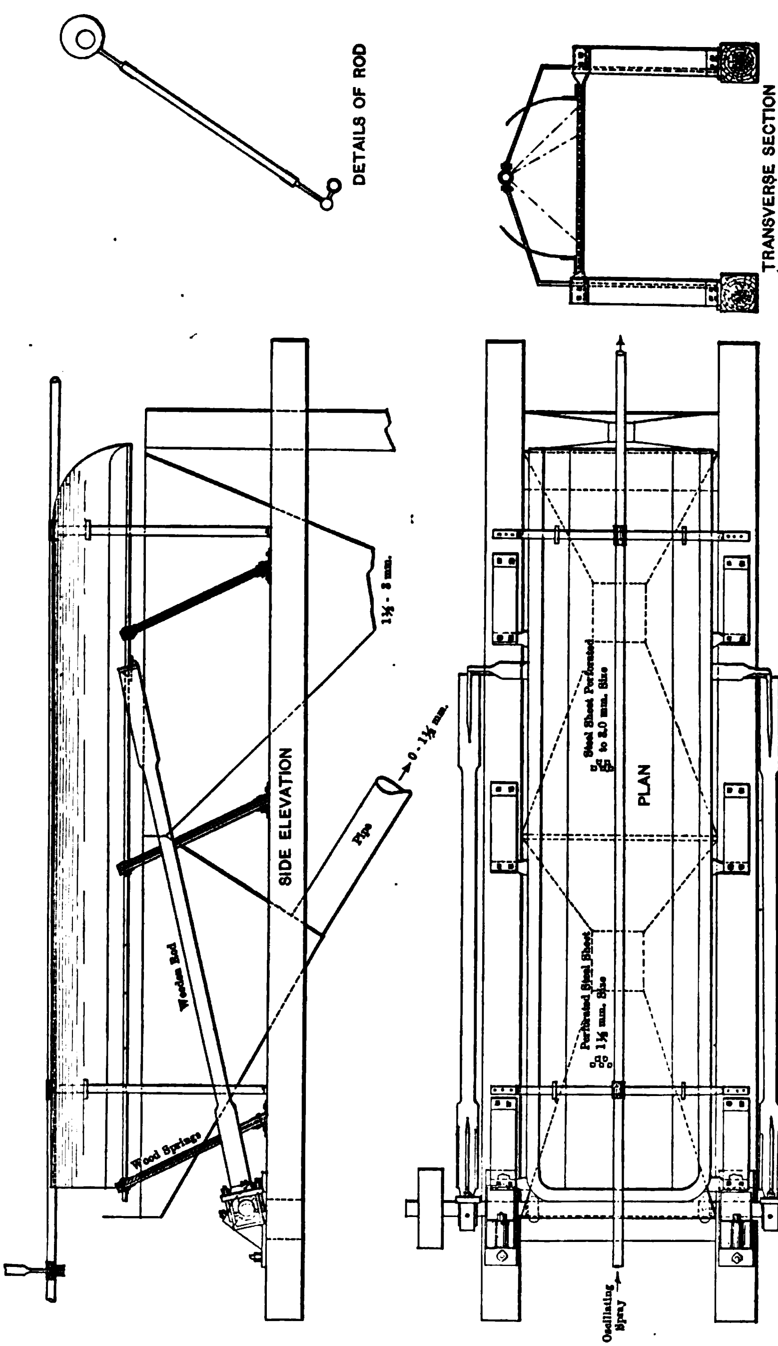

Fig. 1.—The Ferraris Vibrating-Screen.

The Ferraris Vibrating-Screen—These screens are narrow bands of perforated sheet-iron joined by two angle-irons covering the two longitudinal edges. The width of the screen varies from 400 to 800 mm.; the length is indefinite. Fig. 1, showing the screen used for fine sizing, may be regarded as typical of the apparatus. These screens, generally with several sections perforated for different sizes, are mounted horizontally on springs made of several blade-shaped pieces of wood, in length between 400 and 600 mm., inclined about 70° from the horizontal in such a manner as to raise the screen at each oscillation in the direction of the progress of the material. An eccentric or two, and one or two wooden cranks, give to the screen 300 to 400 oscillations per min., with an amplitude of 30 to 40 mm. It is sprayed by a longitudinal pipe, which swings on its axis so as to sprinkle the entire width of the screen. In a complete sizing-system, the first screen, which should also cleanse off the mud, is furnished with superposed traverses to retard the course of the material, and with sprinklers arranged transversely, having jets of water pointed in a contrary direction to the material.[2]

Table I. shows an example of sizing at one of the mills at Monteponi. Screen No. 1 is fed from a hopper closed by an oscillating shovel-slide, which regulates the flow of the material on the screen.

The principal features of the three screens are summarized in Table I.

Screens Nos. 1 and 2 are supported on eight springs, each made of three leaves of beech-wood, 400 mm. in length, 80 mm. wide and 6 mm. thick. Screen No. 3 is suspended on six springs in a box in which the water-level may be regulated. This arrangement serves to clear the obstructions from the holes of the sieve by making it strike the surface of the water occasionally.

The screens may be inclined instead of horizontal, but the inclination must be contrary to the course of the material. In an installation at Monteponi the inclination was brought up to 10 per cent., in order to retard the fall of the material. The

[2] Fortschritte der Erzaufbereitung in Sardinien, *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlvii., p. 229 (1900). *Ore-Dressing*, by Robert H. Richards, S.B., vol. i., p. 342 (1903).

TABLE I.—*Sizing at a Monteponi Mill.*

	Screen No. 1.				Screen No. 2.				Screen No. 3.			
Revolutions of the eccentric per minute				350				355				360
Amplitude of the oscillations, mm				34				32				30
Power employed, h.p				3				2				1.5
Quantity of water for sprinkling per minute, liters				120				60				60
Width of the screen, mm				600				600				600
Maximum quantity of material screened per hour, kg				30,000				8,000				4,000
Diameter of holes in sieves, mm	14	20	30	oversize	5	7	10	oversize	2	3.5	5	......
Classes produced	0-14	14-20	20-30	over 30	0-5	5-7	7-10	10-14	0-2	2-3.5	3.5-5	......
Length of the perforated section, m	2.2	1.5	1.2	....	1.8	1.5	1.2	....	1.20	0.80	......	......
Average weight of material classified per hour, kg	8,800	1,800	2,000	6,000	2,800	1,200	1,200	800	800	1,200	800	......

Class 0-14 goes to feed Screen No. 2. Class 0-5 goes to feed Screen No. 3.

sizing thus gains in precision, but the necessary motive-power also increases with the slope.

The Sanna Screen.—In some mills, for instance, at Malfidano,[3] sizing is pushed to 0.5 mm.; wire-gauze is used instead of perforated sheet-iron, and a long piece of angle-iron is laid on the middle of the screen, on which, if necessary, hammering is done, to remove obstructions from the meshes. With this exception the construction corresponds practically with Fig. 1.

Advantages.—The advantages of vibratory screens over trommels in screening are as follows:

1. The wear is reduced to a minimum, either in consequence of the smaller surface necessary to screen the same quantity of material, or on account of the motion in small jumps which prevents friction on the surface of the screen.

2. The smaller height of the apparatus, which saves cost in construction.

3. A more exact sizing.

4. By using this system of sizing in coal-washeries, breaking the pieces by impact or friction is avoided. The same system may be used to drain off the sized products and to transport them horizontally.

5. Inspection and repair are simpler than with the trommels.

[3] *Rosoconti della riunione della associazione mineraria sarda.* Seduta 18 Novembre, 1900. Sanna. Nota su di uno nuova disposizione dei vagli oscillanti per la classificazione delle sabbie fini.

2. *Classification by Current of Water.*

The methods of mechanical preparation used in countries favored with an abundance of water have given rise almost everywhere to the custom of wasting water in the mills, without considering the inconveniences resulting from too great dilution of the stream which carries the fine sands. In Sardinia the necessity for recovering the water of the washeries, in order to use it again after clarification, has taught the benefit of reducing such dilution to a minimum, and thus removing the hindrance caused by the conduits and the *spitzkasten* to subsequent concentration, while increasing at the same time, by reason of such smaller dilution, the precision of the classification itself.

In sizing by screens, the water used on the first section of the first screen is brought by pipe, together with the grains smaller than 14 mm., to the second screen, from which the water takes the sands below 5 mm., and carries them to the third screen, where the water is collected in the first hopper placed below the screen, with the fine sands below 2 mm. The mixture of water and sands flows through a pipe, carrying the sized sands to the separating-machines.

The most favorable proportion for good sorting by current of water is one portion of solid substance to five of water, but one to ten may be reached without inconvenience. Beyond that proportion, classification becomes more difficult and less exact.

The pipe carrying the sands is generally uniform in section for the entire length, while the inclination should diminish as the sands are delivered to the finishing machines. Generally the slope begins at 30° from the horizontal (50 per cent.), and is reduced in a curve to about 4 per cent. at the first distributing-machine. The following sections have decreasing inclinations, until the last is horizontal.

The distributing-machines for classified material, called hydraulic classifiers,[4] are mounted on the pipe at the points nearest to the separating-apparatus which they feed. The distance

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[4] German Patent No. 31,427; *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen*, vol. xxxiv., p. 42 (1886); *Oesterreiche Zeitschrift für Berg- und Hüttenwesen*, vol. xlii., p. 421 (1894); *Ore-Dressing*, by R. H. Richards, S.B., vol. i., p. 478 (1903).

between two hydraulic classifiers should not be less than 3 m., to give time for the material to separate during the flow.

Classification is made in the pipe by gravity and flow; the heavier grains sinking to the bottom of the pipe, while the lighter grains are carried along with a velocity which in the upper layers approaches that of muddy water. In order to secure good classification, a current of about 0.60 m. per sec. is necessary. A pipe of 100-mm. interior diameter corresponds to 100 liters of water and sand per minute. A total fall of 2 m. is sufficient for a horizontal length of 20 meters.

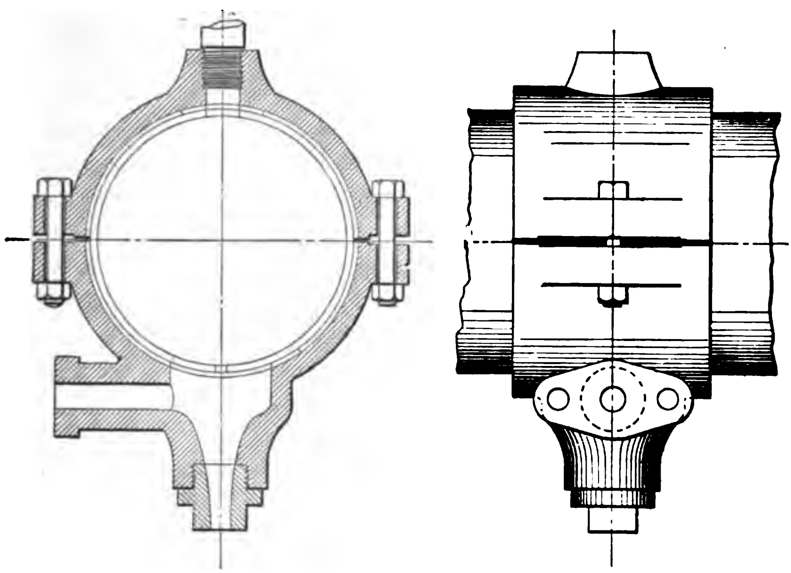


FIG. 2.—DETAIL OF HYDRAULIC CLASSIFIER.

At the point where the classified material should be discharged, a hole of from 10 to 15 mm. is drilled in the lower side of the pipe, and the conduit is surrounded by the hydraulic classifier as in a muff, as shown in Fig. 2.

The sand falls into a lower pocket, which clear water enters from the side, under pressure regulated by a valve, so as to equal the pressure of the water from the principal pipe. The sands flow away with the clear water through a lower opening from 10 to 16 mm. in diameter.

Classification is accomplished more by density than by weight or size; in fact, the heavy ores in a well-regulated con-

duit are almost entirely arrested at the first hydraulic classifiers. In treating a mixture of quartz and galena, the first of these machines delivers nearly 80 per cent. of the galena.

In treating very rich ores, pains are taken to remove all trace of sand from the muddy water before sending it to the settling-ponds. For this purpose, the conduit is lengthened horizontally, and instead of using hydraulic classifiers to draw off the grains which drag on the bottom of the pipe, use is made solely of the outlet-holes, and sands with very little water are obtained from the pipe.

The advantages of this system are evident. There is no obstruction in the works, for the pipes of the hydraulic classifiers are suspended above the separating-machines, to which they are joined by flexible rubber pipes of about 20 mm. diameter. If it is desired to discontinue the use of a separator, it is only necessary to close the orifice of the hydraulic classifier, leaving the clear-water valve a little open, in order that the hydraulic classifier may be always ready to resume its work.

The hydraulic classifier applied to the washing of coal serves to separate the barren material and the portion richest in ash, and to send to the settling-ponds the mud containing the finest particles of coal, which may be briquetted or delivered to coke-ovens.

III. Separation.

1. *Hand-Picking.*

In Sardinia, the grains more than 30 mm. in diameter are picked by hand on an endless wire belt. All the valuable ore is removed, waste being allowed to fall into cars at one end. The belt is supported by two series of rollers. At the extremities it passes around two drums, of which one provides the tension and the other the motive power. The belt is 0.60 m. wide, woven of galvanized wire 3.5 mm. in diameter, twisted in flattened spirals, and joined by transverse wires. It is therefore easy to lay open the belt in order to shorten it, or to change a defective part.

The velocity of the belt at Monteponi is 12 cm. per sec. With favorable ores 20 cm. can be used. The height of the belt from the ground varies from 0.60 m. to 0.75 m., according to the stature of the pickers. For a length of 10 m., 1.25 h.p.

is required. If the feed is very regular, 3 tons of material may be sorted per hour. At Monteponi an average of 1,800 kg. per hour is obtained in picking material of highly irregular size.

The same system of sorting is applied at Monteponi to the tailings from jigs which treat sizes from 20 to 30 mm., and from 14 to 20 mm., in order to extract from this waste material the hydrozincite and spongy zinkiferous limonites, which cannot be separated by gravity from the dolomite. The tailings fall on one oscillating carrier, like the vibrating-screens, but longer and not so wide, and are carried to a picking-belt 8 m. long.

2. *Hydraulic Jigs.*

Concentration of grains from 10 to 30 mm. is effected by hydraulic jigs with two compartments, and in the case of the smaller grains down to 2 mm. by jigs with five compartments.

The construction of the jigs is the same in both cases. Fig. 3 gives the details of a jig with two compartments; it is formed of three cast-iron plates which support the bearings of the eccentric shaft, joined by a wooden casing or wooden walls so as to form two communicating chambers for pistons and screens. This construction has no special advantage beyond facilitating the transportation and mounting of the jigs. But in some details the Monteponi jig differs greatly from those in general use.

The eccentrics have a variable stroke. A first eccentric fixed to the shaft is surrounded by a moving eccentric; the first has a flange which partly covers the second at the side, and both have holes through which the bolt is passed to hold them together. The holes being at a different distance in the two eccentrics, the combination forms a kind of vernier caliper, which allows variation in the eccentricity.

Eccentrics of three sizes are used: one for strokes up to 20 mm.; a second for strokes between 10 and 40 mm., and a third for strokes between 30 and 80 mm.

With five holes in each partial eccentric, 25 combinations of different strokes can be obtained between the two extremes. The superiority of the system consists in the facility with which the eccentricity can be regulated, and in the assurance that this eccentricity cannot vary during the work of the jig. This eccentric is shown in Fig. 4.

The discharge of the concentrated material is made by pipe for the coarser grains; by pipe and suction through the sieve into the hutch beneath[5] for the sands. The pipe varies in diameter from 13 to 51 mm., according to the classes treated. It

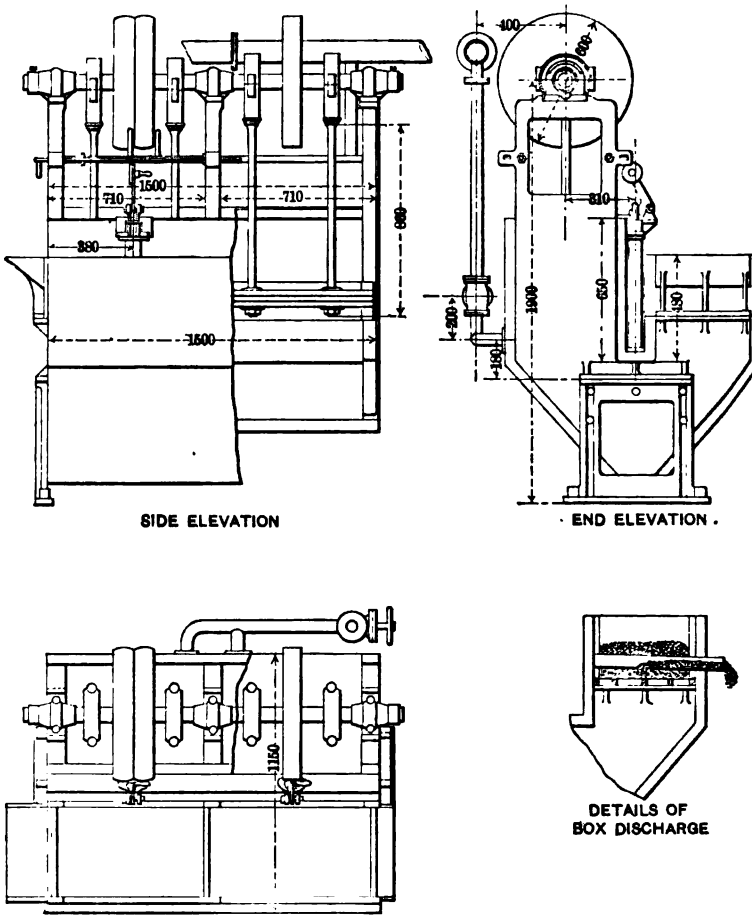


FIG. 3.—TWO-COMPARTMENT JIG.

is placed, slightly inclined towards the outside, and transversely to the screen, at about half the height of the layer of grains. On the bottom of the pipe, in the middle of the screen, a hole

[5] *La préparation mécanique des minerais métallique en Sardaigne.* **Rapport présenté par M. N. Pellati, Inspecteur général des Mines, au congrés de mines et metallurgie de l'Exposition universelle de Paris en 1900.**

is bored, through which the grains with the water rise through the pipe and flow away.

The jig separates the grains in layers of different density. The pipe gives an outlet to the layer of valuable mineral as fast as it rises on the screen. The discharge is made at intervals, especially for the small grains, and is stopped when waste is found mixed with the ores.

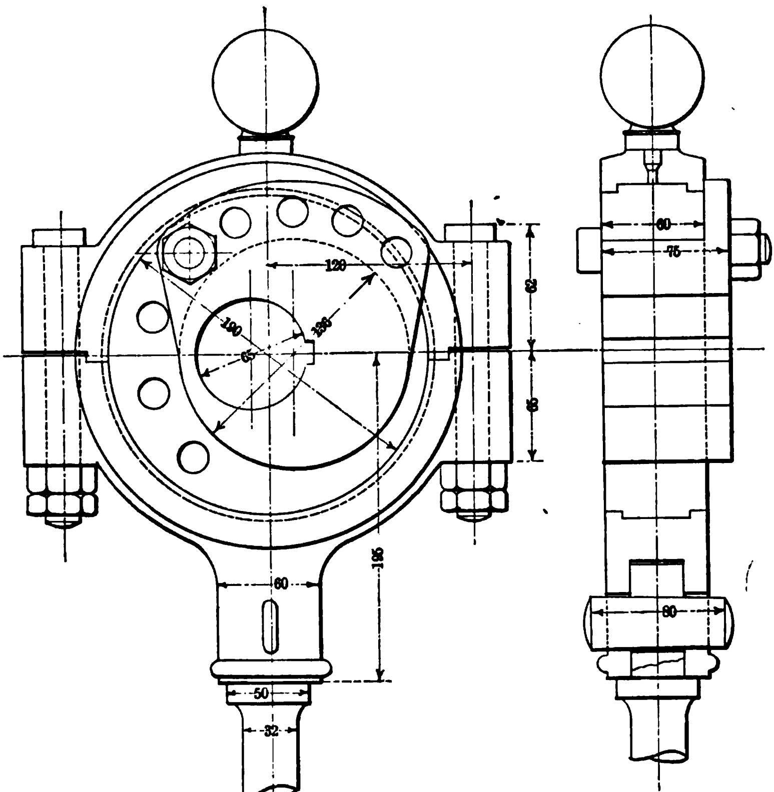


FIG. 4.—ECCENTRIC OF HYDRAULIC JIG.

In jigs treating grains larger than 10 mm., the ore falls on sorting-tables of perforated iron sheets. The jigs have two discharge-pipes, one for each compartment, and the division between the compartments is raised only as high as the pipe, to allow free movement to the upper layer. The first pipe discharges principally a mixture of galena, barite, and cerussite; the second discharges smithsonite and calamine. Sorting on the outside tables gives finished products.

The jigs with five compartments, for sands between 2 and 10 mm., discharge at the same time by pipe-discharge and hutch. A bed of iron disks—the waste from punching-machines—spread on the screen gives the resistance necessary for the separation of the sands and secures the continuous production, above the bed, of a layer of ore, which is forced out through the pipe-discharge as it is formed. To close the spigot, a stopper of some sort is employed, or else a bend, which can be turned upwards when it is desirable to stop the outflow. The screens have perforations larger in diameter than the maximum diameter of the sands, and the products from the pipe and from the hutch of the same compartment have nearly the same composition.

Table II. shows the principal features of the jigs in use at Monteponi.

TABLE II.—*Details of Construction of Jigs at Monteponi.*

	Jigs for Coarse Grains (2 compartments).			Jigs for Sands (5 compartments).			
Class treated, mm.	20–30	14–20	10–14	7–10	5–7	3.5–5	2–3.5
Free width of compartments, mm.	450	450	450	450	450	450	450
Free length, mm.	750	750	750	500	500	500	500
Diameter of the holes in the screen, mm.	10	8	6	10	8	6	4
Diameter of the iron disks which form the bed, mm.	....	....	....	12–16	10–14	8–10	5–8
Stroke of the piston, mm.	40–50	35–45	30–40	20–35	20–30	16–24	15–20
Number of strokes per min.	100	110	120	125	130	150	180
Approximate clear water per min., liters	140	100	75	50	45	40	40
Power consumed, h.p.	1.25	1.1	1	1.5	1.5	1.5	1.5
Material treated per hour, kg	500	450	400	300	300	300	300
Diameter of the discharge-pipes, mm.	51	38	32	25	20	16	13.

All these jigs are directly fed by the vibrating-screens, and perform continuous work. The mixed products from the jigs for sand—for instance, the mixtures of galena, barite, cerussite, and smithsonite—are separated by closed jigs, with one compartment of 0.45 by 1.20 m. free surface of screen, giving beds of different ores, which can be removed by hand at intervals.

3. *Oscillating-Tables.*[6]

For sands below 2 mm. to 0.05 mm. the oscillating-table has been in use since 1898. This apparatus is well known also in

[6] French Patent No. 22,874; Belgian Patent No. 142,072; English Patent No. 22,374; German Patent No. 105,097; Austrian Patent No. 1,354.

other countries, since the Fried. Krupp Grusonwerk bought the patent and introduced it into almost all mining regions.

The oscillating-table is built in two types: one for fine sands below 2 to 0.5 mm., the other for sands of 0.5 down to 0.05 mm. They are identical in principle. The former is shown in Fig. 5. A rectangular table is placed horizontally in the direction of the movement, and slightly inclined in the other direction. It rests on six inclined springs, and receives an oscillating motion from an eccentric, exactly like the vibrating-screens; the table is covered with linoleum. Its inclination may be regulated during the progress of the work by wedges placed between the table and the frame, which rests on the springs. The mixture of water and sand from the hydraulic

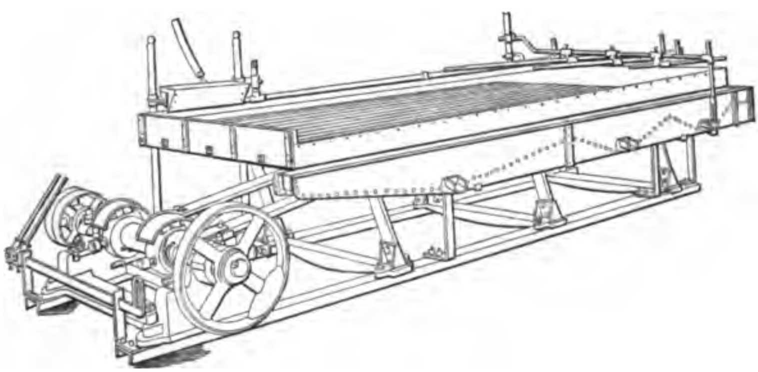


FIG. 5.—OSCILLATING-TABLE FOR SANDS FROM 2 TO 0.5 MM.

classifier is distributed by a short longitudinal hopper to the upper angle at the side of the eccentric, while the water flows away transversely. The grains are discharged on the table, running in parabolic lines, according as their specific gravity is greater and their diameter smaller. The spray-pipe placed at the upper side of the table pours out a slender stream of water which holds the grains suspended. Lengthwise grooves depressed in the linoleum prevent a too rapid fall of the heavy grains (without stopping the fall of the waste), and force them under the short spray-pipes placed at the end opposite to the hopper, where they are divided into groups of different character and specific gravity, and pushed towards the outlet.

The second type, or small oscillating table for sands finer than 0.5 mm., is trapezoidal in form, and has no spray-pipe at

the outlet; and the hopper at the entrance is replaced by a screen placed a few centimeters above the table, with which it oscillates. The purpose of this screen is to remove the excessively large grains, and to deliver the material evenly. This delivery is made first upon a raised section (*A*, Fig. 6) less inclined than the rest of the table, *B*, so as to hold the grains, while the accompanying water flows away transversely. The two sections, *A* and *B*, carry semicircular grooves, which diminish in depth towards the side of the outlet. The grooved area is limited by a parabolic line, as shown in Fig. 6.

This table serves also to treat the mixed products from the larger table of the first type, and all the other intermediary fine products. For this work, a screen is used with perfora-

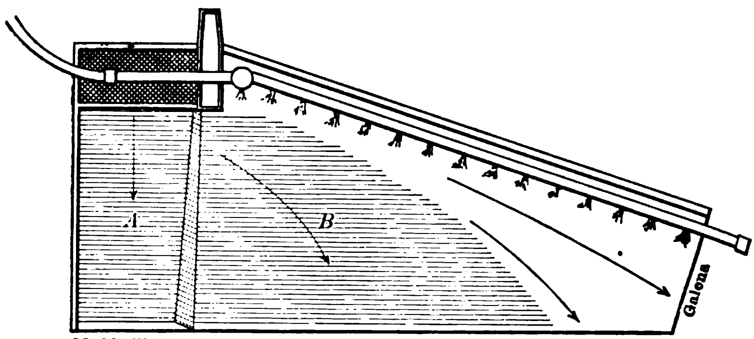


FIG. 6.—OSCILLATING-TABLE FOR SANDS FINER THAN 0.5 MM.

tions of 1 mm., corresponding to the maximum diameter of the grains which the table can treat successfully.

Principal Data of the Two Types of Oscillating-Tables.

	Large Type.	Small Type.
Length of table, m., ...	3.5	2.25
Width of table, m., ...	1.5	1.40–0.5
Oscillations per min., ...	340	350
Amplitude of oscillations. mm., . . .	16–18	12–15
Water used per min., liters, ...	50	10–15
Necessary force, h.p., ...	0.75	0.5
Dry weight of material treated per hr., kg., .	400–600	200–400

4. *Comparison Between Hydraulic Jigs and Tables.*

In all old mills, sands of 1 to 2 mm., and even below 1 mm., are treated by hydraulic jigs with suction. The defects of this system are numerous. In the first place, sizing on screens,

and still more by trommels, of grains smaller than 2 mm., is difficult and far from exact; and the work of the machines for classification is costly and delicate. Suction-jigs for fine sands never give well-finished products; for below 2 mm. the pipe-outlet which serves to regulate the thickness of the bed, while maintaining on the screen of the jig a constant layer of ores of the same composition as that which sifts through the screen, cannot be used. The metallic value, or average specific gravity, of the ore which sifts gradually diminishes from one end of the jig to the other, without any sharp separation between the ores of different quality. The oscillating-table has the additional advantage of using less power in order to obtain better products, as can be seen by comparing the results of the two systems:

	Oscillating-Table.	Hydraulic Jig.
Net weight of material treated per hour, kg., .	400–600	300
Clear water per min., liters, ...	50	40
Motive power per machine, h.p., ...	0.75	1.50

When we consider that half of the products of the suction-jig are submitted to an extra concentration or separation, we see that the advantages of the oscillating-table are increased to about 50 per cent., and, apart from the best results in work, there is also considerable economy in installation.

5. *Belt for Treating the Slimes.*[7]

When argillaceous ores are treated, there are found in the last products from the hydraulic classifiers very fine ores, which run over the tables without sinking into the grooves. These ores have a diameter below 0.02 mm., and would go to enrich the slimes in the settling-ponds if there were no way to separate them. The method employed for this purpose serves, also, to recover the useful ores which might be drawn away by the water accompanying the products of the tables and jigs. It consists of a rubber belt, slightly inclined transversely, 0.60 m. wide, stretched over two drums, of which one serves to give the motion and the other the necessary tension. Every 60 cm. it is supported by rollers with regulated inclination, so as to have the belt almost horizontal at the side of the

[7] *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlii., p. 421 (1894).

entrance of the slimes, while the inclination is progressively increased at the side of the outflow of the products. Fig. 7 shows such a belt.

The pulp, reaching the belt through a rubber pipe, with almost no velocity, flows out on the belt, on which it deposits the solid particles, leaving the clear water to flow away. The motion of the belt carries the deposits to the water-sprays, which force them to the edge of the belt, making the lighter portion flow out with the water. The results are different products, some finished and some middlings, which can be treated on a second belt.

The force necessary to operate the slime-belt is merely that required to turn the belt on the pulleys without a load. A belt

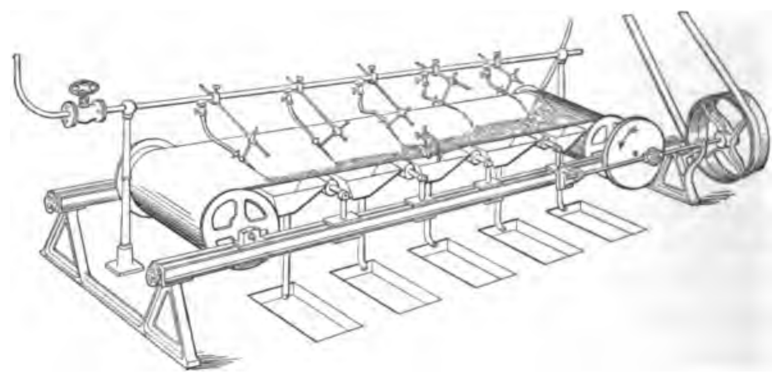


FIG. 7.—BELT FOR TREATING SLIMES.

4 m. in length treats 40 liters of slime, and requires 60 liters of clear water per minute.

According to the degree of concentration of the slime, more or less material can be treated on the belt, up to a maximum of 240 kg. of dry material per hour. The average is 100 kg., for, generally, concentration of the slime is avoided, so as to prevent losses by being carried away.

There are belts made two or three times the length, with two or three sections of introduction for the slime to be treated.

The belt does the same work as the Linkenbach revolving buddle; but it has the superiority over the latter of occupying less space. The life of a rubber belt, carefully managed, is about two years.

6. *Separation of the Middlings.*

Middlings from the process of concentration may be divided into two classes:

1. Mixtures of ores of too close a specific gravity to be easily separated at the first operation; for instance, cerussite and barite, blende and pyrite, calamine and limonite; or certain mixtures of sufficiently different specific gravity, but produced in the work of concentration, which are further treated either to remove a mineral which is found in the raw material in too small a quantity to be directly concentrated, or to take away from the waste all trace of useful mineral. Such are mixtures of galena with cerussite and barite, zinkiferous limonite and dolomite, as well as the ferruginous calamine and dolomite at the calamine-mill of Monteponi.

2. Mixed minerals which require a previous breaking to separate them.

As observed in connection with the hydraulic jigs for coarse grains, the mixtures of the first class are separated by stratification on the closed hydraulic jigs with one compartment, removing the products by hand, and layer by layer, as soon as stratified.

The fine-grained mixtures which contain waste are usually concentrated in a special section of the washery, provided with suitable classifying- and separating-apparatus.

Separation of the mixtures of the second class begins with crushing, more or less extreme, according to the nature of the material. The machines for crushing used in Sardinia are the stone-breaker, the rolls and the ball-mill. Of the first two types in Sardinia there is nothing special to be said.

The ball-mills used are chiefly the Krupp and the Ferraris.

Ferraris Mill.—The Ferraris wet ball-mill[8] possesses the advantages of great simplicity of mounting and small requirements of space and power for the same capacity. The steel plates which form the lining do not need to be adjusted, being held in place by the lateral steel walls and the sand formed by the crushing of the ores. There being no central shaft, large lumps of ore can be introduced into the mill, and workmen can easily enter for repairing and cleaning.

[8] United States Patent No. 726,521, Apr. 28, 1903.

The mill is made in two forms: one for coarse grinding (from 5 to 15 mm.), the other for fine grinding (from 5 to 0.5 mm.). The following description of the first form may serve for both, except as to the differences mentioned below.

The mill consists of a drum supported on four carrier-wheels and driven by a spur-gear securely fixed to the drum, which engages with a spur-pinion keyed to the counter-shaft. The drum is divided by an annular perforated partition into two compartments. The larger or crushing-compartment is $61\frac{3}{8}$ in. in diameter by 30 in. long. It is lined with manganese-steel plates with projecting ribs, and contains about 1,000 pounds of forged steel balls 4 in. and 6 in. in diameter. The smaller or screening-compartment, about 10 in. in length, is divided into a series of pockets by means of a cone projecting into the crushing-compartment, and a series of radial partitions extending therefrom. The periphery of this compartment is open, and is surrounded by a screen of the desired mesh. The material passing through the screen falls into a housing surrounding the lower half of the screening-compartment.

The ore to be crushed is fed into the crushing-compartment with the water, and, when reduced to pieces smaller than the holes in the annular partition, passes through into the screening-compartment, where the material which is fine enough passes out through the screen, and the oversize is elevated by the radial partitions until it slides back on the surface of the cone into the crushing-compartment, where it undergoes further crushing.

The drum is rotated at 20 revolutions per minute, and requires 5 to 6 h.p. at its full load. The capacity at this speed on quartzose ore, broken by crusher to pass through a 2-in. ring, is approximately:

Mesh of screen, ...	12	16	20	30
Capacity, in tons per 24 hr., ...	35	30	25	20

The weight of the mill, including balls, is approximately 7.5 tons.

In this type, the peripheral plates are detached from the inner walls of the drum, leaving between them and the projecting bars a space of 12 mm., through which the water carries into the sizing-compartment the grains below 12 mm. In the second or fine-grinding form (Fig. 8), the peripheral steel plates are close

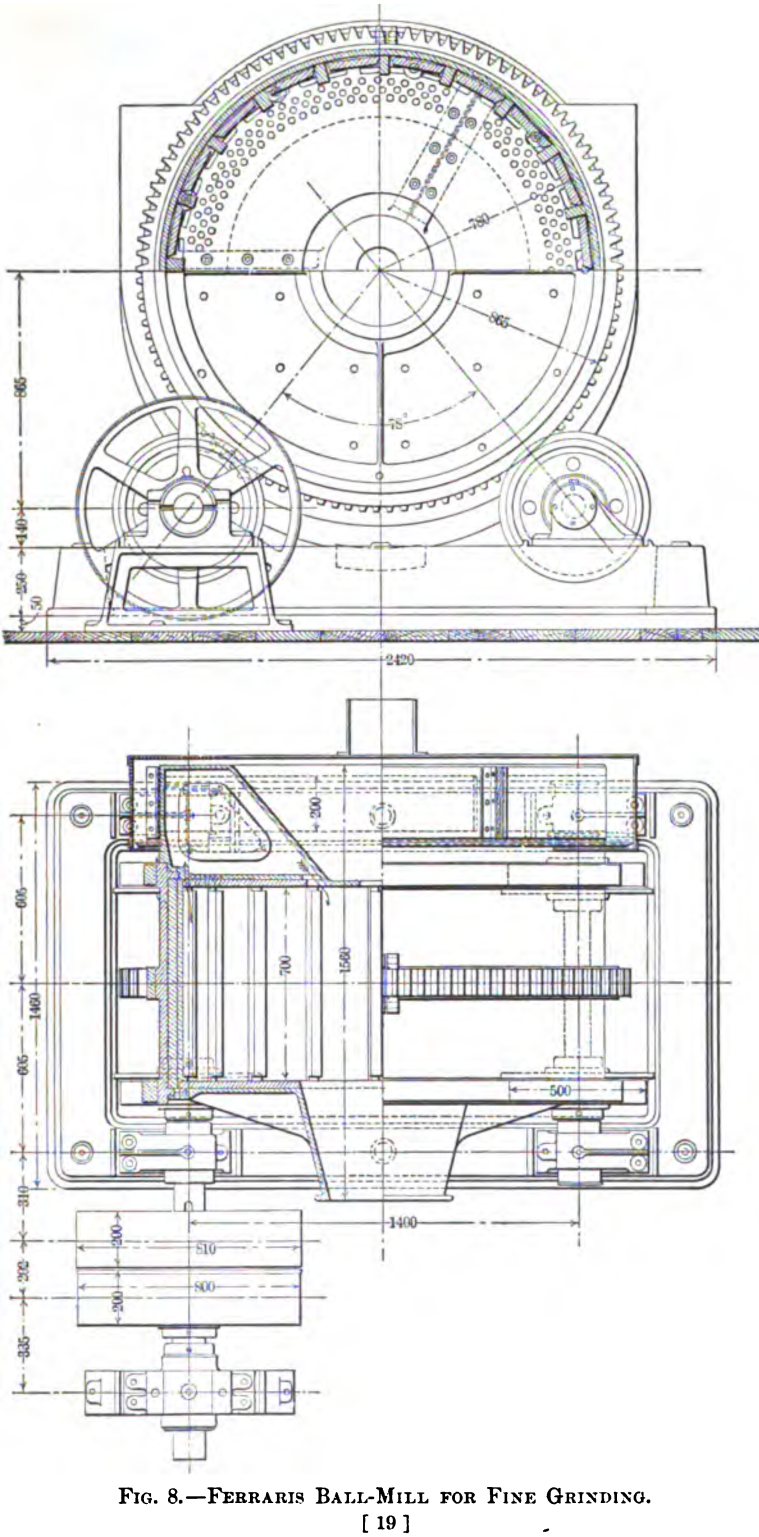


FIG. 8.—FERRARIS BALL-MILL FOR FINE GRINDING.

to the inner walls of the drum, and the water with grains below 10 mm. runs out through holes in the walls which divide the ball-chamber from the sizing-chamber. In both forms the screen is at the periphery of the sizing-chamber, and the material rejected by the screen is raised by the radial partitions to the point where it can slip over the exterior surface of the cone and return to the crushing-chamber.

A Ferraris ball-mill requires 7 h.p., with 20 rev. per min., and 80 liters of water per min. The quantity crushed per hr. depends on the quality of the ore and the size. In general, the product is greater from brittle ores like quartz than from tough minerals like diabase. A quartzite mineral in large pieces is crushed to 3 mm. at the rate of 4 tons in 3 hr., or 1.33 tons per hr. If the ore has been broken beforehand to 50 mm., 1.5 tons per hr. can be crushed to an average size of 1.5 millimeters.

The broken ore is sent to the separating-machines after having been sized, if a screen of more than 2 mm. in size is used. In this case the sizing is accomplished by the vibrating-screen. If the crushing is pressed below 2 mm., hydraulic classifiers are applied to the pipe which carries the water and sand, as described above.

In the mill at Monteponi for the fine crushing of mixed ores, the first hydraulic classifier feeds a jig of five compartments; the others feed the Ferraris oscillating-tables.

At the Rosas mine, there are five ball-mills forming five sections. The ball-mills receive the material which has been broken by the stone-breaker to 2 in. and crush it to 2 mm., at the rate of 1.5 tons per hr. per mill. But diabase impregnated with blende and galena is found to be very difficult to crush.

Each section is composed of one ball-mill, two jigs and three oscillating-tables. There is one special section, composed of a distributing-trunk, a classifying-pipe, and eight oscillating-tables, to treat the middlings from the five crushing-sections.

7. *Magnetic Separation.*

The mixed products of the ores of zinc and iron are treated by a reducing calcination, followed by magnetic separation.

Calcination.—This is performed in the well-known Oxland cylindrical furnace, of 1.30 m. exterior diameter, 1 m. inte-

rior diameter, 10 m. length, and 6.2 per cent. slope. The furnaces make an average of 15 rev. per hr., and serve to calcine the calamine below 15 mm. in size as well as the mixtures of calamine and iron, to be later separated by the electro-magnet. In preparing the mixtures for magnetic separation, 2 per cent. of reducing carbon is added to the ores.

At Monteponi there are three rotating-furnaces, which gave, in 1906, the following results:

Hours of work in the year,	15,800
Weight of crude material introduced into the furnaces,	15,137.6 tons.
Weight of calcined product,	12,184.8 tons.
Total consumption of lignite,	2,296.85 tons.

It should be observed that the fuel is a lignite rich in ash, which gives 23 per cent. of clinkers; it is burnt on a barred grate in a thick layer with injection of air and steam under the grate. The fuel is partly gasified, and the gas burns in the furnace with the air heated around the hearth and on the hot calcined charge which falls from the furnace. A rotating-furnace can calcine a ton of crude ore, and give 773 kg. of calcined product per hour. The total fuel-consumption is 145 kg. per ton of crude ore, or 188 kg. per ton of calcined product.

In 1906, the cost of calcination per ton of calcined product, was:

	Francs.
Fuel,	3.2500
Hand-work,	0.7376
Steam and motive-power,	0.5000
Oiling and repairs,	0.2651
Total,	4.7527
Per ton of crude material,	3.825

Preparations are in progress to install in Sardinia new revolving-furnaces, which will have a tubular boiler between the furnace and the chimney, and thus avoid the expense for motive-power and the injection of steam. In this case the calcination of a ton of crude ore will cost only 3.5 francs at the most.

Magnetic Separators.—At Monteponi there are two installations of magnetic separators, one with six electro-magnets, rubber belts which carry the classified ore, and a large cross belt which removes the iron-ore. In order to distribute the material to the six electro-magnets, it is raised by a bucket-

elevator, and sized by a vibrating-screen into six classes; that is to say, 0–0.5; 0.5–1; 1–2; 2–4; 4–6; and 6–10 mm. The material over 10 mm. is crushed and returned after crushing to the magnetic separator.

The distance between the belt which carries the ore and the poles of the electro-magnet varies from 20 to 40 mm. An apparatus with six electro-magnets treats on an average 1 ton per hr., and requires 2 h.p. and a current of 6 amperes at 110 volts.

After separation from the iron, the zinkiferous product is dressed on closed jigs to remove the calcined dolomite and the small amount of lead-ore which it contains.

In the year 1906 one of these magnetic plants treated 6,373.97 tons of calcined material containing 25.98 per cent. of zinc. After separating the iron, and jigging, a marketable product was obtained of 2,264.12 tons with an average of 40.87 per cent. of zinc, representing 66.47 per cent. of the zinc in the original calcined ore and the removal of 17.31 per cent. of iron.

The remainder goes into the middlings products, which are set aside, and into the tailings from the jigs.

The iron oxide contains 10 per cent. of zinc, which cannot be removed without resorting to chemicals. To enrich still further the valuable calcined calamines, single and portable magnetic separators are used at Monteponi.

One of these drum separators[9] takes 2 amperes at 110 volts, and treats between 500 and 600 kg. of material per hour.

Another, with scissors arrangement, is similar to the multiple separators, but is stronger and can use up to 20 amperes. There are adjustable branches and an oscillating transporter.

8. *Calamine Mill, Monteponi, Sardinia.*

The ores treated consist of the economic minerals, calamine, smithsonite, and limonite, with some galena, cerussite, siderite, and sphalerite. The gangue is limestone and dolomite, with some barite. The smithsonite and galena are very compact, and, upon crushing, remain largely in the coarse products, while the calamine and cerussite are very friable and break up

[9] *Engineering and Mining Journal*, vol. lxxxii., p. 1129 (1906).

into fines. The galena carries about 0.2 per cent. of silver, but the cerussite contains very little silver.

Ore from the mine-cars is dumped to (1).

(1) Grizzly having 80-mm. openings between the bars. From the mine; delivers oversize, via hopper, to (2) and undersize, via hopper, to (3).

(2) Picking-table. From (1); delivers calamine to market, mixed zinc-iron-lead ore to (12), limonite to market and waste rock to dump.

(3) Two Ferraris waving-screens, each having three screening-sections, with holes 14, 20 and 30 mm. in diameter respectively. From (1); deliver material on 30 mm. to (7), material from 30 to 20 mm. to (6), material from 20 to 14 mm. to (6) and material from 14 to 0 mm. to (4).

(4) Two Ferraris waving-screens, each having three screening-sections, with holes 5, 8 and 10 mm. in diameter respectively. From (3); deliver material on 10 mm. to (6), material between 8 and 10 mm. to (8), material from 8 to 5 mm. (8) and material from 5 to 0 mm. to (5).

(5) Two Ferraris waving-screens with two screening-sections, with holes 1.5 and 3 mm. in diameter respectively. From (4); deliver material on 1.5 mm. to (8) and through 1.5 mm. to (9).

(6) Twelve 2-compartment jigs. From (3) and (4); deliver mixed lead- and zinc-ore to (12), calamine to market and tailings to dump.

(7) Wire picking-belt. From (3); delivers rich calamine to market, ferruginous calamine to market, poor zinc-iron, middlings to (12), limonite to market and waste rock to dump.

(8) Sixteen 5-compartment jigs. From (4) and (5); deliver lead-zinc middlings to (12), rich calamine to market, ferruginous calamine to (32), limonite to market, poor iron-zinc middlings to storage and tailings to waste.

(9) Hydraulic classifier. From (5); delivers spigots to (10) and overflow to (11).

(10) Four 5-compartment jigs. From (9) and (10); deliver cerussite to market, lead middlings to (10), calamine to market, rich iron-zinc middlings to (26), poor iron-zinc middlings to storage and tailings to waste.

(11) Six Ferraris waving-tables. From (9); deliver cerus-

site to market, calamine to market, iron-zinc middlings to (26) and tailings to waste.

Recrushing Department.

(12) Ferraris wet ball-mill. From (2), (6), (7) and (8); delivers to (13), crushes through 8 millimeters.

(13) Ferraris waving-screen, having three screening-sections, with holes 1.5, 3 and 5 mm. in diameter respectively. From (12); delivers material on 1.5 mm. to (14) and material through 1.5 mm. to (16).

(14) Three 5-compartment jigs. From (13); deliver middlings to (15), calamine to market, ferruginous calamine to (32), rich iron-zinc middlings to (19), poor iron-zinc middlings to storage and tailings to waste.

(15) Four-eompartment jig. From (14); delivers lead-ore to market, lead-barite middlings to (35), calamine to market, iron-zinc middlings to (26) and tailings to waste.

(16) Hydraulic classifier. From (13); delivers spigot to (17) and overflow to (18).

(17) Five-compartment jig. From (16) and (17); delivers cerussite to market, lead-zinc middlings to (17), calamine to market, ferruginous calamine to (32), iron-zinc middlings to (26) and tailings to waste.

(18) Two Ferraris waving-tables. From (16); deliver cerussite to market, calamine to market, iron-zinc middlings to (26) and tailings to waste.

Auxiliary Middlings Department.

(19) Ferraris waving-screen, having two screening-sections, with holes 5 and 8 mm. in diameter respectively. From (14); deliver material on 5 mm. to (20) and material through 5 mm. to (22).

(20) Four 5-compartment jigs. From (19) and (22); deliver lead middlings to (21), rich calamine to market; ferruginous calamine to (32), iron-zinc middlings to (26), poor middlings to storage and tailings to waste.

(21) Four intermediate jigs run intermittently and discharged by hand-skimming. From (20); deliver cerussite to market, lead-barite middlings to (35), calamine to market, poor iron-zinc middlings to (26) and tailings to waste.

(22) Ferraris waving-screen, having two screen-sections, with holes 1.5 and 3 mm. in diameter respectively. From (19); delivers material on 1.5 mm. to (20) and material through 1.5 mm. to (23).

(23) Hydraulic classifier. From (22); delivers spigots to (24) and overflow to (25).

(24) Two 5-compartment jigs. From (23) and (24); deliver cerussite to market, zinc-lead middlings to (24), calamine to market, rich iron-zinc middlings to (26), poor iron-zinc middlings to storage and tailings to waste.

(25) Three Ferraris waving-tables. From (23); deliver cerussite to market, calamine to market, iron-zinc middlings to (26) and tailings to waste.

Magnetic-Separation Department.

(26) Revolving cylindrical furnace. From (10), (11), (15), (17), (18), (20), (21), (24) and (25); delivers to (27).

(27) Ferraris waving-screen, having six screening-sections, with holes 0.5, 1, 1.5, 2.5, 4.5 and 6 mm. in diameter respectively. From (26); delivers material to (28).

(28) Ferraris magnetic separator. From (27); delivers limonite to market, and non-magnetic tailings coarser than 2 mm. to (29) and finer than 2 mm. to (31).

(29) Three intermediate jigs run intermittently and discharged by hand-skimming. From (28); deliver limonite to market, calamine to market, middlings to (30) and tailings to waste.

(30) Intermediate jig run intermittently and discharged by hand-skimming. From (29); delivers calamine to market, middlings to storage and tailings to waste.

(31) Three 4-compartment jigs. From (28) and (31); deliver limonite to market, middlings to (31), rich calamine to market, ferruginous calamine to (32) and tailings to waste.

(32) Revolving cylindrical furnace. From (8), (14), (17), (20) and (31); delivers to (33).

(33) Ferraris waving-screen, having seven screening-sections, with holes 0.5, 1, 1.5, 2.5, 4.5, 6 and 10 mm. in diameter respectively. From (32); delivers to (34).

(34) Ferraris magnetic separator. From (33); delivers calamine to market and limonite to market.

(35) Revolving furnace for decrepitating barite. From (15) and (21); delivers to (36).

(36) Ferraris waving-screen, having six screening-sections, with holes 0.5, 1, 1.5, 2.5, 4.5 and 6 mm. in diameter respectively. From (35); delivers material on 6 mm. to market, from 4.5 to 6 mm. to (38), from 4.5 to 1 mm. to market, from 0.5 to 1 mm. to (37) and below 0.5 mm. to market.

(37) Three 4-compartment jigs. From (36) and (37); deliver lead-ore to market, mixed lead-ore to (37), barite to market, calamine to market and tailings to waste.

(38) Intermediate jig run intermittently and discharged by hand-skimming. From (36) and (38); delivers lead-ore to market, lead-zinc middlings to (38), calamine to market and tailings to waste.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Coal-Briquette Plant at Bankhead, Alberta, Canada.

A discussion of the paper of Mr. Parker, presented at the New York Meeting, February, 1908, and published in the present number of the *Bi-Monthly Bulletin*, pp. 355 to 362.

WILLIAM H. BLAUVELT, Syracuse, N. Y.:—Is the coal itself from which the briquettes are made of good quality for steaming-purposes?

MR. PARKER:—It is an anthracite coal mined near Bankhead and used on the Canadian Pacific Railroad. It contains about 83 of carbon, 8 of ash, and 8 per cent. of volatile material. With regard to briquetting of a mixture of fine coal and coke-dust, I understand that a plant has been installed near Detroit in which coke is mixed with anthracite; also the plant of the United Gas Improvement Co. near Philadelphia is briquetting a mixture of anthracite coal, the resultant briquettes being used in the gas-retorts.

MR. BLAUVELT:—The purpose of the Detroit briquette-plant of the Solvay Process Co. has been partly to use up the coke-breeze from the by-product ovens and partly to utilize the pitch. There is no necessity for mixing anthracite with the coke-breeze, but the supply of breeze is limited, and anthracite is added in order to increase the output. Soft coal also is mixed with the anthracite and coke; but in the practice at Detroit it has been found that unless the briquetting is very well done the addition of much soft coal makes a smoky briquette. If used by consumers accustomed to anthracite, it is desirable to make a briquette which is almost smokeless.

The problems encountered in suiting briquette-manufacture to American conditions are very different from those in European practice. American coals are relatively low-priced and of good quality, so that in most manufacturing districts, at least in the East, the natural supply of coal is well adapted to the requirements of the manufacturers. Anthracite coal as pre-

pared for domestic consumption is an almost ideal fuel. In Europe, on the other hand, coal is high-priced and very many deposits are non-coking, so that the fine coal can only be made available for use by forming it into briquettes.

There are three different fields in the United States for the development of the briquette-industry :

1. In the East, where the domestic trade is practically supplied by prepared sizes of anthracite, and where steam-coals are of excellent quality and relatively low in price. In this field coal-briquettes offer a substitute which can be sold at a lower price than anthracite. Moreover, there are also a number of special purposes for which briquettes are adapted.

2. In the middle West, in regions like the Hocking valley, where the conditions are similar to those in parts of Europe, the coals are non-coking, and the fine coal, as such, is to a large extent worthless. If formed into briquettes, however, it makes an excellent fuel.

3. In the far West, where there are large deposits of lignite. Many of these lignites, however, crumble into a coarse powder after an exposure of a week or two to atmospheric action, but if briquetted they form an excellent fuel, and withstand indefinitely atmospheric action.

Many briquette-enterprises have been started in the United States, but only a few have met with success. In some cases failure has been due to improper methods of manufacture, but oftener it has been caused by a neglect to give proper consideration to the commercial conditions; either the available raw material was not adequate or suitable, or else the process selected did not produce a briquette suited to the local market conditions.

The manufacture of briquettes may be divided into two classes: large briquettes, and small briquettes, or eggettes. The former weigh from 5 oz. to 20 lb. each, the larger size being about the weight of the largest briquettes made in Europe; this class is suitable mainly for industrial purposes, and can best be made on presses of the reciprocating type. The small briquettes, or eggettes, usually weighing from 1.5 to 3 oz., are best made on a rotary press of the Belgian type. If an attempt is made to produce the smaller briquettes on reciprocating presses, the output is so reduced as to make the operation commercially

impracticable. On the other hand, rotary presses are not adaptable to briquettes weighing more than 5 or 6 oz. each.

JAMES DOUGLAS, New York, N. Y.:—The only enterprise in the West that I know of that has made briquettes is the Arizona Copper Co., which installed a plant in order to utilize the refuse from its large coke piles; and though not in operation at the present time, it saved the company from a shut-down two years ago when coke was very scarce. I understand that the total cost of the briquettes at that time, including the tar for binder, which had to be imported, amounted to about $1.50 per ton.

With regard to briquetting lignites, I think the trouble would be to secure a proper supply of tar for the binder. At present, tar is extremely expensive in the lignite-fields. If by-product coke-ovens were introduced for coking bituminous coal, the heavier products from the distillation of the tar would then be available for a binder. In addition, the creosote would be extremely valuable for use as a timber-preservative. To my mind, the most important question at present in the far West is the introduction of by-product coke-ovens to supply creosote for timber-preservation, tar as a briquette-binder, ammonium sulphate as a fertilizer, in making which the sulphur going to waste from our furnaces would be utilized. If the farmers would only use artificial manures before their land is actually impoverished, they would not have to sue the smelters for damage to their crops, for the sulphur would actually nourish instead of destroying plant-life, when converted from noxious gas into one of the ingredients for artificial fertilizer.

MR. BLAUVELT:—One of the reasons why the by-product oven has not been introduced into the far West is the question of the market for the by-products. It is possible that the briquette-industry and the by-product oven may be developed together in that region, the briquette-plant consuming the pitch from the tar, and the ammonium sulphate being used as a fertilizer.

The cost of manufacturing briquettes, of course, varies greatly with local conditions, the size of plant, etc. For a plant of moderate size the operating-cost might be from 50 to

75 cents a ton, not including the binder. Some of the prominent manufacturers of pitch, which is recognized as the principal binder for briquettes, have appreciated the fact that if the briquette-industry is to grow to considerable proportions in the United States, the question of pitch for the binder must have special consideration. This condition may develop the use of a special hard pitch which can be shipped in bulk under a low freight classification, and avoid the expense of barrels or other packages.

DR. DOUGLAS :—I have more doubt about the ammonia than about the tar. The Santa Fé Railroad is the only one that is importing creosote in large quantities. Creosote, of a value of 3 cents per gal. in Europe, costs the Santa Fé road 8 cents a gal., yet, in spite of this fact, it is preferred to zinc sulphate. If coke-oven by-products could be used with any advantage in the West, I do not think there would be any difficulty in getting rid of the tar, but the farmers have not yet been taught to use ammonium sulphate as a fertilizer.

C. G. ATWATER, New York, N. Y.:—Dr. Douglas has suggested that if a plant of by-product ovens were erected in the far Western States there would be no difficulty in disposing of the tar in the form of pitch for briquette-making, but that a market for ammonia would be doubtful. It seems to me that under present circumstances no difficulty need be anticipated. It is merely a question of extending the plant. If ammonium sulphate is made, a market could be found for it as a fertilizer. During 1907, Japan alone imported 64,000 tons of sulphate of ammonia from England, paying freight around Cape Horn or through the Suez canal, so that there should be no difficulty in disposing in Japan or elsewhere of the 2,000 or 3,000 tons that a plant of moderate or large size would produce. The conversion of ammonia into sulphate, however, requires a supply of sulphuric acid to the extent of about 1.25 tons of chamber acid to a ton of finished sulphate. A plant for making the acid could be erected at the ovens, as has been done in several cases elsewhere, or the acid could be obtained from some one of the existing acid-works on the Pacific coast, if freights were favorable; or, as is frequently done in Germany,

the ammonia could be concentrated to strong crude liquor to lessen the shipping-weight, and transported to a Pacific coast port where acid could be obtained at a favorable cost, the transformation to sulphate being made at that port.

There is good reason to believe that an investigation of the matter from a commercial point of view, in connection with a prospective plant of by-product ovens, would disclose a favorable field for the disposal of ammonia on the lines above mentioned.

The sale of the ammonia from a plant in the far West has seemed hitherto an easier matter than the creation of an outlet for the tar. The tar, from this point of view, was the obstacle to the introduction of the by-product oven in this territory. But the growth of the briquette-industry and the confidence that has been expressed at this meeting of the Institute that this growth is on a stable foundation and liable to receive considerable extension in the near future, would effectually remove this obstacle. With a good prospect for the advantageous disposal of these two important by-products, it would seem probable that the installation of by-product ovens to treat the coals of the far Western mines is not very distant. Concerning the demand for coke, there is reason to believe that the market will easily absorb more than it has ever yet received.

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

Piping and Segregation in Steel Ingots.

A Discussion of the Paper of Prof. Howe. (*Bi-Monthly Bulletin*, No. 14, March, 1907, pp. 169 to 274.)

P. H. DUDLEY, New York, N. Y. (communication to the Secretary*):—The characteristics of Prof. Howe's metallurgical papers are, that he is able, from the mass of confusing evidence on the subject, to make an analysis and present hypothetical and essential principles in concrete form for consideration and discussion. I can appreciate, from the practical side of the subject, the arduous labor of collecting and investigating the data that is essential to prepare the paper. Much of the data necessarily came from material of preceding years of manufacture in which there was allowed time for chemical reactions of the recarburizer, and for the elimination of the oxidation-products before teeming the ingots. This condition gave a favorable time-element to free the metal from slag† and other impurities, but, in allowing the ingot to cool before charging in the furnace, the time-element entered as a detrimental factor in the development of the pipe or shrinkage-cavities, which gave an ingot-structure deficient in soundness. The interpretations from such material must be made with due allowances for the methods of manufacture, and must be given proper weight, as general facts, in subsequent arguments.

The difficulties under which investigators labor are not easily surmounted in differentiating between reliable and unreliable data incident to variables of methods of manufacture, chemical composition of the alloys of steel, mediocre practice and that of the highest state of the art.

Modern practice and large outputs in Bessemer steel have reversed the effects of the time-element by cutting short the chemical reactions of the recarburizer and the elimination of

* Received Feb. 18, 1908.

† The term slag is used in a general rather than in a strictly technical sense. Traces of sulphide of manganese are often associated with silicates of manganese in the same thread or seam.

the oxidation-products before teeming, but the full shrinkage of hot to cold metal has been checked by charging the ingots into furnaces after teeming, and blooming at least with the equalized original heat of the freezing metal.

This practice in the manufacture of rails has reduced the great number of true piped-rails in the early steel rails from cold ingots, though many are still produced.

The segregation is concentrated, intensified in effects, and is more harmful in the large ingots, which are kept in vertical position from the teeming to the blooming, than was the case with those of smaller dimensions, thrown down in the pits after stripping, laid on cars and charged into horizontal furnaces, for equalizing the heat for blooming. There are many defects of ingot-structure incident to the segregation, as the split heads, due to included slag in the bearing-surface, many of which are independent of any pipe in the web, though there are combinations of a pipe in the web with some split heads.

There are other defects of ingot-structure due to entrained slag, oxides and gas, particularly at the junctions of the columnar structure in the corners of the molds in the upper parts of the ingots. The darkening and then spawling of metal from the upper corners of the head, under traffic, is the indication of the deficient and unsound ingot-structure, which is quite distinct from general piping or segregation. The entanglement of impurities in the jutting pine-tree crystals of the freezing metal may form a region of unsoundness between an outer envelope of the columnar structure and the central core, which, in the bearing-surface of the head, becomes oftentimes separated at the joints of the upper rail of the ingot when under heavy traffic.

These defects of ingot-structure are not included in Prof. Howe's paper, but should be in any discussion, in my opinion, where unsound ingot-structure from piping or segregation is under consideration.

The failure of rails is due to many causes, of which a number, as flow of metal in the bearing-surface of the head, "mashing" of the ends, and flaking of metal from the upper corners of the head, are due to insufficient cubic or elasticity of volume of the metal to receive, sustain and distribute the pass-

ing wheel-effects to the rest of the section. The deficiency may be due to a low grade of metal or entrained slag, oxides or other impurities in an intended high grade of metal from the chemical composition.

Prof. Howe's Introduction divides the paper into three parts: the first treats of the causes and the restraining of piping in steel ingots, the second considers the causes and the restraining of segregation, and the third proposes certain precautions in engineering specifications concerning these two defects.

In Part I. he states:

"I infer that the pipe is chiefly due to what I call the virtual expansion of the outer walls of the ingot in the early part of the freezing. I find that the upper and smooth-faced part of the pipe probably forms while the interior is still molten, but that the lower, steep, and crystal-faced part probably forms in metal which is already firm."

I have not been able to observe in a great many ingots which I have cut to trace the pipe, that any of the lower part had opened in metal which had previously solidified. I frequently find in ingots from special composition that they pipe from the top nearly to the bottom, while in others, with care, the pipe is eliminated with 5 to 6 per cent. discard; but, as previously stated, I have never found an instance in which the metal had separated after being firm, as inferred by Prof. Howe, which, if it did not occur in a cold ingot, would probably not in one bloomed before it was allowed to cool. He designates five causes which may co-operate to limit the depth of the pipe, and finds that blow-holes, sagging, and the progress of freezing from below upwards are usually effective. He finds that the pipe may be lessened by casting: 1, in wide ingots; 2, in sand molds; 3, at the top instead of at the bottom; 4, slowly; 5, with the large end up; 6, by the use of a sink-head or other means of retarding the cooling of the top; 7, by permitting blow-holes to form; and 8, by liquid compression.

Prof. Howe, writing in general, without entering into specific details, has not discussed the effect of chemical composition in the setting of the ingots, except in reference to Brinell's well-known experiments, though under 7, by permitting blow-holes to form, there is some reference to chemical composition.

Brinell's experiments evidently were made upon smaller

ingots than those generally used for rails the past two decades, for they need decided modification in this country, particularly with direct metal.

I have found that by modification of the chemical composition to suit the conditions at a particular mill, the setting of the steel could be improved, and in small ingots for 3 lengths of 30-ft. 100-lb. rails, sound ingots were produced, under the usual discard of 6 to 8 per cent. from the top.

This is the day of specifications, the consensus of opinion being that those of the same chemical composition apply with equal force to any mill in the country, and that the product will be the same. This is not the case. Different ores, different sizes and shapes of ingots, different systems of rolling and treatment modify the product either for wear of the rails or their safety as girders.

Mills which make 5 or 6 rails per ingot, and cut the blooms into two parts and roll in 2 and 3 lengths, produce a safer product as a girder than if they rolled the 5 and 6 lengths as a single bar and afterwards cut it into rail lengths.

I made more than 600,000 tons of rails from 1890 to 1898 in my sections, principally the 65-, 70-, 75,- 80-, 95- and 100-lb. weights, and but few of these rails, after 10 to 16 years' service, have developed pipes. It is probable that as the head becomes more worn, instances will occur in which the head splits, which may be due to a combination of a pipe and slag in the surface, or lateral splitting of the head from the slag in the bearing-surface, without a trace of a pipe in the web of the rail. The extensive investigation the past two years upon slag, oxides and other impurities in the bearing-surface of the heads of the rails, leaves no doubt as to their existence, and the cause of some types of rapid wear and failure of the rails as girders. Minute defects in ingot-structure of little importance a decade since, under the present wheel-loads are the incipient sources of failure of the rail-heads.

The necessity of providing a range in the specifications for the chemical composition, so that it may be adjusted to local conditions, is imperative to produce sound ingots free from pipes and other defects.

I have made experiments in the casting of ingots with the large end at the top. The results were favorable, and confirm to

a certain extent what has been said by Prof. Howe. There are other advantages in casting with the large end up, in permiting more of the impurities to escape from the setting steel. without being caught in the corners of the columnar structure, The methods of teeming ingots in use at the present time are not suitable for this class of work. It would be necessary to reconstruct the plants for this purpose.

The most important feature which I have found essential for making sound ingots, is that more time should be allowed after recarburizing either in the converter or in the ladle before teeming, as brief agitation has not accomplished wholly the desired result. Discussing the subject with one of our most experienced steel-makers recently, he said that he considered that this was a necessary condition of procedure for a reliable product. Prof. Howe does not distinguish between high-carbon and low-carbon steels. It is a well-known fact that steels of 10 or 15 points in carbon usually rise in the ingot and do not form pipes, and that it is necessary to cast such metal in bottle-mouthed molds and cap them to prevent the steel from overflowing. Increase the carbon, and the tendency to form a pipe from what is usually considered shrinkage of the metal becomes more pronounced, unless other methods are used to obviate it.

Teeming with a small-sized nozzle is also conducive to producing sound ingots and freedom from pipes and seams.

The segregation of the ingots, while more or less associated with the piping of the upper part of the ingot, may also be quite independent. The manufacture of my sections of rails and according to my specifications has given comparatively few pipes after years of service; the ingots were teemed 16 in. square or less on the base, and after stripping thrown down into the pit and loaded on cars and charged into horizontal furnaces. The opportunity for the metalloids to segregate and rise to the top of the ingot in the horizontal furnaces was not so favorable as when the ingots are charged directly into vertical furnaces. The segregation for the high-carbon rails was not so marked as is the case at the present time with ingots which are kept in a vertical position from the teeming to the blooming.

The general experience of teeming shows that in small ingots

which set quickly the segregation is confined or limited to a marked extent. The size of the ingot must, however, depend in a degree upon the material which is to be subsequently produced. Large, flat ingots are essential for boiler-plate and structural work. Those of large dimensions are required for armor-plate, also for large shafts for steam-ships. The size of the ingots for rails is also being increased, and the practical results from the 19- by 23-in. ingots of short length, compared with those of 19-in. square and longer length, are decidedly in favor of the larger stubby ingot.

The study of the pipe in ingots is usually made when the steel is cold and the entire shrinkage from hot to cold metal has taken place. I have recently had the opportunity of seeing some of the modern large-sized ingots for rails and other material cut through the center, and also the cores taken from the center of large ingots. The work that I did from 1890 until 1900, when cupola-metal was used and care taken in the composition, shows, by actual experience in the track, that sound ingots have been made in which piping is the least of their defects. This can be repeated in larger ingots with the advance in metallurgical knowledge of to-day.

I made 95-lb. high-carbon low-phosphorus rails from 14-in. ingots at the works of the Bethlehem Steel Co. for the Boston & Albany Railroad in 1891 and 1892, and gave 5 or 6 min. in the ladle for the oxidation-products to escape from the chemical reactions of the recarburizer. The 75-lb. rails for Dr. Webb's Mohawk & Malone Railroad were also made at the same time. These high-carbon low-phosphorus rails were rolled while Mr. John Fritz was general superintendent of the plant, for he was the only manufacturer who admitted at that time that such rails could be made. These were premium rails, and the late Mr. William Bliss, President of the Boston & Albany Railroad, paid $2 per ton additional for the high grade of steel, and Dr. Webb also paid the same premium for part of his rails. Mr. Bliss considered it economical to secure as good material as possible, and their service, most of them, after 16 years, being still in the track, has proved the wisdom of the initiatory procedure.

Prior to this time Mr. Fritz had constructed his 48-in. blooming-train for 16-in. and larger ingots, but it cracked the skin

of the ingots so much more than the former 26-in. blooming-train, that I had my choice of which size of ingots to use, and I chose the 14-in. ingot after many tests, which made 2 lengths of 30 ft. rails, while the 16-in. made 3 lengths.

The Boston & Albany rails were 0.60 in carbon and 0.06 in phosphorus, as also a part of the Mohawk & Malone rails. The heats, after recarburizing in the converter, were poured and remained in the ladle from 5 to 6 min. to allow the chemical reactions to take place and oxidation-products to escape before teeming the ingots, which were stripped, then thrown down in the pits and charged into horizontal furnaces for equalizing the heat before blooming. The 26-in., 3-high blooming-train of 11 passes was used, and the blooms had a discard until sound steel was obtained, then chipped under the steam-hammer, again charged into horizontal furnaces for reheating and then rolled in 11 passes into rails. They were finished at between 950° and 1,000° C., as nearly as could be measured by the Siemens copper-ball and water pyrometer. We had not then advanced to the scientific requirements of sawing the rails 0.01 in. shorter for each second after leaving the rolls, and frequently rolling so cold as to damage the rail as a girder. (?) Rolling the rail cold for wear is one factor to be considered, but this in any case must not exceed the safety-factor as a girder. The new type of sections with 0.5 in. thickness of edge can be rolled too cold for safety, as has occurred in some experimental trials. The Bethlehem rails on the Boston & Albany Railroad, after 16 and 17 years' service on heavy grades and sharp curvatures, have lost only about ⅛ in. in height for the large volume of traffic which has passed over them. They show by the sound inside corner of the head or the inside corner containing inclusions of slag, oxides, or gas whether the rails were from the bottom or the top of the ingot. The fractures of these rails, on both the Boston & Albany and the Mohawk & Malone railroads, have been exceedingly few after so many years of service. The rails have excellent wearing-properties and are also tough as girders.

More than 600,000 tons of rails with carbon 0.60 and phosphorus 0.06 per cent. were rolled at Scranton, Pa., in my sections. These were rolled from 14- to 16-in. ingots of sufficient length for three 30-ft. rails. Special effort was made to secure

a composition which would set well in the ingots and be free from pipes. The number of stickers broken under the drop was sufficient to show the general soundness of the ingots.

Commencing December, 1892, the rails from the ingot were marked *A*, *B*, and *C*, the upper rail, *A*, the middle, *B*, and the lower, *C*. These letters can be found upon the rails and the wear of each easily traced. But few of them have pipes in the web and only a few split heads have occurred. The ingots were thrown down in the pit, loaded on cars and charged into horizontal furnaces for equalizing the heat, and then were rolled direct without reheating. The *A* rails show that occasionally there were entrained slag, gas, and other impurities at the junctions of the columnar structure of the small-cornered molds. The *B* and *C* rails hardly show after many years' service any breaking down of the inside running-edge of the rails, either upon curves or tangents. The fractures of these rails in the track, even under heavy traffic, have been slight, and but few more have occurred in the *A* than in the *B* or *C* rails. Some of the upper ends of the *A* rail have been crushed or have worn slightly faster than the other portions under heavy traffic.

It is noticed in taking sections of the different lettered rails, that in the *A* rail the impurities are largest in amount, as would be expected. There is often a well-defined central core, which is not as readily seen in the *B* rail, and only rarely noticed in the *C* rail.

Prof. Howe, in his paper, thinks that the matter of noting the different rails or blooms from the upper part of the ingot has been until now entirely overlooked. It has been my practice since December, 1892, to mark the rails rolled as follows, the rail from the upper part of the ingot being marked *A*, from the middle, *B*, and from the lower, *C*. In case of four or five rails I have used the letters *D* and *E*. This practice was never carried out at the Carnegie mills, but it was by the Lackawanna Iron & Steel Co., at Scranton, and also at their Buffalo mill. The practice of designating the different rails from the ingot is now becoming quite general, and will soon be required of every mill in the country.

The difficulties with these rails made from the 14-in. ingots, and subsequently in 1894 from 16-in. ingots, are not due so

much to piping and segregation as to the collection of the impurities in the upper *A* rail. When vertical furnaces, in 1898, were used for charging the ingots to equalize the heat, the results of segregation became more pronounced. In the horizontal furnaces, the metalloids, separating from the molten metal, would rise towards the upper side of the ingot and be harmless in most cases, while in the vertical furnaces they rise and concentrate in greatest amount in the upper part of the *B* or the lower part of the *A* rail.

When the ingots were charged in the horizontal furnaces the high carbons did not segregate sufficiently to be of serious consequence, as is shown by the wear of the rails.

Rails rolled from the present large ingots, 19 in. square upon the base and from 5.5 to 6 ft. long, the segregation becomes decided, and often included slag is found in the bearing-surface of the head, which spreads laterally under the moving wheels and produces a split head, while there is scarcely a trace of pipe in the web.

Rails made from large ingots, 20 by 23 in. on the base and short in comparison to the width, show fewer split heads from segregation and a smaller quantity of entrained slag in the head of the rail than those made from the smaller ingots of greater length. There is one brand of rails rolled from the comparatively small but long ingot, in which the split heads in five or six years of service amount to 8 or 9 per cent. of the entire product for July, August or September rollings.

The shortening of the time in the Bessemer department from recarburizing to teeming has contributed to the inferior quality of much of the large outputs of Bessemer rails. The segregation in the long ingots, particularly when the phosphorus is at 0.10 per cent., is a serious matter with our present service of high-speed trains.

Observing the different brands of rails, containing 0.10 per cent. of phosphorus, regardless of the carbon-content, the wear is not nearly so satisfactory as from the high-carbon and low-phosphorus rails. The large amount of slag which is found in the head of the rails is now well established in different brands and its composition is becoming known.

The corners of the molds at one mill I had made of larger radius, and this has helped to some extent to relieve the col-

umnar structure in the corners of as much entrained slag and impurities as was formerly found in the corners of smaller radius, but the shape of the mold alone does not permit of the escape of an unduly large amount of slag and impurities under rapid teeming. It is a requirement of sufficient time, and the Bessemer departments should not be run too rapidly, in order that each converter or ladle should be given ample time for the chemical reactions and oxidation-products to escape. This arrangement requires more ladle-capacity in order to give sufficient time for each operation, which of itself would not necessarily reduce the output of the mill when properly planned.

The high phosphorus-content is a serious question, and unless some relief is quickly found it may be necessary to use the basic open-hearth process for reducing this content of phosphorus. Steel made by the basic open-hearth process, in which proper time is allowed for the escape of the oxidation-products, has proved exceptionally tough and free from included slag. It gives evidence of being well adapted not only for a slow rate of wear, but also for safety in the sections as a girder. The heavy bases in the new design of rails are so massive that the time required for the distribution of strains makes them more sensitive to rapid strains than the lighter bases of some of the present rails.

These questions will require time to investigate thoroughly and find out how to roll properly the sections for the slowest rate of wear and the greatest safety as girders.

The cutting of the lettered rails into sections and examining the segregation, shows that for the horizontal furnaces those effects were not as marked as those from the larger ingots in the vertical-fired furnaces. The ingot-structure as a manufactured product is also shown, and it is a good way to investigate and study the subject. It now seems almost safe to say, from present studies, that the ingot-structure will improve more in the coming year than it has in the past decade.

PROF. HOWE:—I think that Dr. P. H. Dudley has put his hand on the thing which we have hitherto overlooked—namely, the opportunity for the oxide and slags to be removed

from steel. I think the late experiences with electric furnaces show that he is right, if you consider what the electric furnace does. Of course, the electricity as electricity has nothing to do with it, but what it does is to allow the metal to stay stationary for a long while. The Heroult process removes much sulphur also, but that by itself does not suffice to explain the improvement. It seems to me the great improvement is due to the ample time for the gradual removal of the inclosed slag.

HIRAM W. HIXON, Philadelphia, Pa.:—Concerning the segregation of ingots in copper-converting and silver-refining, in these processes a large quantity of gas is given off by the metals at the time of solidification. In the case of silver, oxygen absorbed from the air during the process of smelting is given off with such force at the time of solidification that it shoots out sprouts, proportionate to the size of the bar or button that is solidifying. Copper as finished in a converter has the property of holding SO_2 gas in solution until it solidifies. I have frequently observed, in turning down a converter, after the charge has been finished properly and is in a quiescent condition, that as soon as it begins to chill a little it will begin to boil, giving off SO_2, and, when it is poured into molds, this action is very much accelerated and the gas given off is of greater strength and is very irritating to the nostrils and the eyes. If the charge is poured into a ladle, and that ladle-ful of copper poured into a furnace, the copper can be held in a molten condition until the gas is given off, and then comparatively clean castings of copper can be made from the same copper that would have given very rough bars if cast direct. I have often seen little copper-volcanoes at work on the top of a copper bar, and sometimes they are really dangerous. In the Bessemer process of making steel a very large quantity of air is blown through the steel or through the cast-iron being converted into steel, and there is more or less similarity in the absorption of gases in this process and in the case of silver and copper. It is undoubtedly true that segregation of the gases towards the top of the ingots and the good rails coming from the bottom, is due more to the occluded gases than to any other cause. Therefore, the open-hearth products make better

rails, simply because the steel is held for a long time in a molten state and every opportunity is given for the occluded gases to escape.

That point is made clear also by the fact that steel made by an electric smelting-process is much superior to steel made by any other process, even though its analysis is similar, because there is no included gas in it. Therefore, if you want to improve the ingots of the Bessemer process the opportunity is offered, instead of casting direct from the ladle, to put that steel into a large reservoir or furnace for that purpose and hold it for a considerable time, giving an opportunity for the included gases to escape. Segregation will be found to be much less after the steel has given off its gas than it will if cast immediately from the ladle.

A. A. STEVENSON, Burnham, Pa.:—Referring to Prof. Howe's able and exhaustive paper on the Piping and Segregation of Steel Ingots, the theories advanced and the facts brought forth are extremely interesting. Prof. Howe reaches a number of conclusions based on certain data and some rather close reasoning. How far these conclusions agree with results in actual practice, is a natural question. In the main, as far as our own experience is concerned, the facts agree with the conclusions of Prof. Howe.

In the beginning, the following remarks, unless otherwise stated, refer to high-carbon acid open-hearth steel, such as is used for tires, of the following approximate analysis:

	Per Cent.
Carbon,	0.60 to 0.70
Silicon,	0.20 to 0.30
Manganese,	0.60 to 0.80

The ingots vary in weight from 1,500 to 6,000 lb., and are bottom-cast in groups.

As far as the supposed genesis of a pipe in a solidifying steel ingot is concerned, the illustrations given in Prof. Howe's paper do not, in our opinion, give the correct shape, although the description in the text does agree with the actual shape indicated by Fig. 1, which shows a section of a 16-in. bottom-poured ingot tipped over 15 min. after it was poured and the fluid portion of the steel emptied out. Fig. 1 shows the rapidity with which an ingot of this size solidifies.

With regard to the question of increased tendency to segregate with increased size of ingot, Prof. Howe, in his discussion to-day, brings out the point, as a result of experiments made since his original paper was presented, that apparently there is not a greater tendency to segregate with an increase in size of ingot.

In the paper referred to by Prof. Howe, which was presented

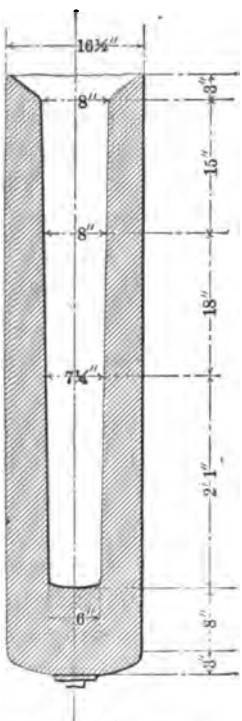


FIG. 1.—SECTION OF 16-IN. INGOT TIPPED AND EMPTIED 15 MIN. AFTER POURING.

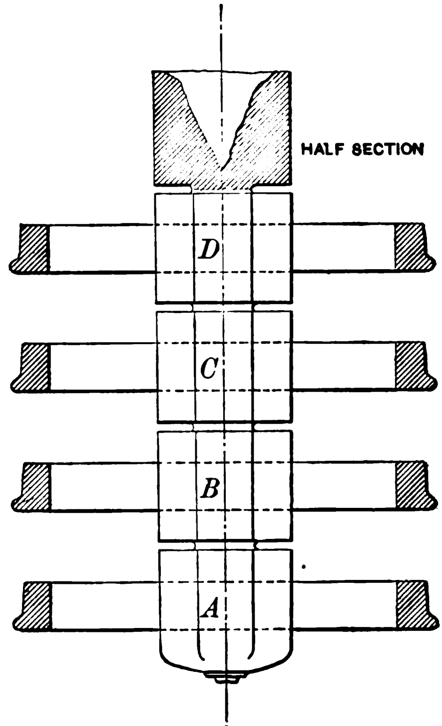


FIG. 2.—TIRES ROLLED FROM DIFFERENT PORTIONS OF INGOT.

by Mr. Kent and myself at the Chicago meeting in 1893 (*Trans.*, xxiii., 637), we brought out the fact of the large amount of segregation that sometimes occurs in small ingots, and gave several examples. One of the most pronounced cases of segregation was in an ingot of about 400 lb. weight, and the worst points of segregation did not seem to be at the bottom of the pipe, but along the sides. In this ingot the segregation was so pronounced that it showed plainly on etching,

and was readily distinguishable from the rest of the metal by the porous appearance, apparently due to the greater ease of attack by etching acid. The segregation appeared in pockets or globules, and the line of demarcation between the segregated portion of the ingot and other portions was very pronounced.

In a number of other cases, in ingots varying from 400 to 800 lb. in weight, we have found segregated spots in which one or all three of the elements—carbon, phosphorus, and sulphur—have shown from 50 to 100 per cent. more than in the balance of the ingot. No doubt the segregation was even greater, but there was no way of getting drillings that did not contain some of the metal surrounding the porous or segregated spots. The ingots in question were cast in iron molds, and consequently must have cooled very quickly, which, according to all reasoning, would tend to decrease the segregation, and the question arises whether or not, in these cases, the concentration of the elements was not due to an extrusion or squeezing-out process, owing to the rapid freezing.

It may be interesting to know that in tires made from short ingots the segregation was as readily detected by the etching-process in the tire as in the ingot itself. Since our paper was read, in 1893, we have made a great many tests of larger ingots and tires from larger ingots. We have found that segregation in ingots as high as 6,000 lb. in weight, even around the pipe, was comparatively small, but in no case was the segregation as extensive as in the small ingots. In all our experiments with long ingots and tires made from them we have never found segregation so pronounced as to show porous spots and streaks by etching. This, in itself, tends to show that the segregation is not altogether an element of size. Our opinion is that the condition of the bath at the time the heat is poured has a great deal to do with the amount of segregation, and that the careful manipulation of the bath in the furnace is as important as the size or shape of the ingot, if not more so.

Some years ago we installed 50-ton furnaces for making tire-steel. It was a question whether or not the steel in heats of this size could be made as homogeneous as the steel in smaller heats, which was the then prevailing practice in the manufacture of tire-steel. In order to settle this point we made several

hundred tests by taking tires from the bottom or *A* billet, as shown in Fig. 2, and analyzing borings and turnings from these tires; then taking the tires from the top or *D* billet of same ingot and analyzing borings and turnings from same. It is understood, of course, that in the manufacture of tires there is a small plug punched out which might contain segregation, as it is from the exact center of the ingot. In practically all cases we found no greater variation in the analyses of the borings and turnings from the *A* and the *D* tires from the same ingot than would be represented by variation in chemical manipulation. In a few cases the analysis of the borings from the top or *D* tire showed slightly higher results, but in no case was this difference sufficient to cause any disquietude. The *D* tire is just under the pipe, and if there were any degree of segregation below the pipe we think that it would have been detected, in view of the large number of tests that were made.

In addition to these tests, a great many tires were cut up and analyzed at various points to see if the uniformity extended throughout the mass, and never was any greater difference found than might be accounted for by allowable chemical variation. Many ingots were also cut up, and, in the immediate vicinity of the pipe, there were never found such extreme cases of segregation as occurred in small ingots.

Fig. 3 shows the section of a 20-in. ingot which was laid off in 2-in. squares, and drillings taken from the intersections for analyses. Table I. gives the results from various drillings, which show a slight segregation in the vicinity of the pipe and along the axis of the ingot. In the main, the analyses show great uniformity.

As far as the mode of solidification is concerned, we find that in the grade of steel used for tires the solidification is invariably not of the "onion-skin" type, but of the "land-locking" type, which proceeds by sending out large pine-tree crystals. We have found this to be the case in medium steel such as is used for locomotive forgings, in soft steel and high-carbon crucible-steel, and we believe it is the usual mode of solidification.

In the discussion of rail-steel and ingots from which rails are made, much has been said concerning columnar structure, but we have never yet found a case in our own practice.

TABLE I.—*Analyses of Drillings from 20-in. Ingots.*

Hole.	Comb. C.	Si.	P.	Mn.	Sul.	Hole.	Comb. C.	Si.	P.	Mn.	Sul.
1	0.660	0.280	0.048	0.68	0.039	94	0.630	0.275	0.058	0.67	0.048
3	0.634	0.270	0.046	0.68	0.040	95	0.630	0.265	0.059	0.67	0.047
7	0.660	0.270	0.052	0.66	0.041	96	0.650	0.270	0.052	0.65	0.046
10	0.640	0.280	0.055	0.68	0 047	99	0.660	0.260	0.054	0.68	0.043
11	0.645	0.280	0.052	0.65	0.038	101	0.645	0.275	0.054	0.67	0.041
14	0.645	0.280	0.054	0.66	0.042	103	0.645	0.2[illegible]0	0.055	0.65	0.048
17	0.620	0.275	0.050	0.66	0.039	104	0.645	0.260	0.052	0.68	0.047
18	0.630	0.280	0.055	0.67	0.043	105	0.640	0.270	0.057	0.65	0.046
19	0.654	0.280	0.055	0.68	0.045	107	0.670	0.275	0.054	0.67	0.043
20	0.645	0.280	0.054	0.68	0.043	111	0.669	0.280	0.053	0.66	0.044
21	0.660	0.280	0.052	0.67	0.041	112	0.645	0.280	0 056	0.67	0.046
25	0.660	0.280	0.052	0.67	0.043	113	0.645	0.265	0.053	0.66	0.047
26	0.660	0.280	0.052	0.68	0.043	114	0.660	0.280	0.053	0.68	0.047
27	0.640	0.275	0.054	0.66	0.043	115	0.650	0.270	0.054	0.69	0.045
29	0.660	0.270	0.052	0.67	0.045	121	0.660	0.280	0.056	0.67	0.050
30	0.645	0.280	0.055	0.66	0.044	122	0.641	0.260	0.053	0.66	0.048
34	0.645	0.280	0.056	0.68	0.044	123	0.651	0.275	0.055	0.67	0.048
35	0.660	0.275	0.056	0.66	0.044	130	0.654	0 280	0.053	0.67	0.044
36	0.660	0.275	0.055	0.66	0.043	131	0.640	0.280	0.057	0.68	0.041
39	0.654	0.270	0.055	0.67	0.047	132	0.666	0.280	0.055	0.69	0.045
40	0.660	0.280	0.053	0.68	0.052	140	0.690	0.275	0.054	0.67	0.039
42	0.693	0.285	0.057	0.68	0.052	149	0.670	0.275	0.053	0.67	0.042
43	0.645	0.280	0.053	0.67	0.047	156	0.646	0.265	0.052	0.68	0.046
46	0.660	0.278	0.056	0.66	0.047	158	0.650	0.275	0.052	0.66	0.046
48	0.654	0.280	0.052	0.67	0.046	160	0.645	0.275	0.054	0.66	0.047
49	0.660	0.275	0.054	0.65	0.046	172	0.660	0.280	0.054	0.67	0.046
51	0.660	0.280	0.054	0.68	0.052	176	0.654	0.275	0.053	0.66	0.041
52	0.645	0.280	0.054	0.65	0.050	180	0.660	0.260	0.054	0.67	0.043
54	0.645	0.270	0.055	0.65	0.045	191	0.642	0.275	0.053	0.68	0.042
57	0.660	0.280	0.053	0.67	0.046	194	0.645	0.270	0.051	0.68	0.040
58	0.660	0.275	0.054	0.67	0.046	197	0.645	0.270	0.053	0.68	0.045
60	0.660	0.280	0.052	0.66	0.050	199	0.630	0.260	0.054	0.66	0.042
61	0.645	0.265	0.053	0.65	0.043	203	0.640	0.270	0.055	0.66	0.044
66	0.654	0.280	0.055	0.66	0.045	207	0.660	0.280	0.054	0.67	0.041
67	0.680	0.280	0.053	0.65	0.049	221	0.645	0.260	0.051	0.66	0.042
69	0.660	0.280	0.052	0.65	0.046	230	0.630	0.270	0.053	0.65	0.040
70	0.660	0.280	0.055	0.68	0.044	253	0.642	0.275	0.053	0.66	0.042
75	0.645	0.270	0.054	0.65	0.047	255	0.645	0.280	0.055	0.68	0.041
76	0.645	0.280	0.054	0.68	0.048	257	0.648	0.275	0.053	0.68	0.039
78	0.675	0.270	0.052	0.64	0.046	259	0.651	0.280	0.052	0.67	0.042
79	0.654	0.265	0.053	0.66	0.047	261	0.648	0.280	0.055	0.66	0.043
84	0.630	0.270	0.053	0.67	0.044	280	0.660	0.275	0.053	0.66	0.041
85	0.645	0.275	0.054	0 67	0.042	284	0.642	0.260	0.052	0.65	0.041
86	0.690	0.275	0.058	0.66	0.048	288	0.645	0.260	0.045	0.68	0.041
87	0.675	0.265	0.054	0.67	0.047	298½	0.630	0.280	0.052	0.67	0.043
88	0.660	0.280	0.052	0.68	0.048	302	0.660	0.270	0.053	0.65	0.043
91	0.675	0.270	0.055	0.66	0.045	305½	0.645	0.275	0.053	0.64	0.040

Streaks, such as are frequently referred to in the discussion of steel for government work, and which at the present time seem to be giving the government considerable uneasiness, we do not have.

Referring to Prof. Howe's remarks with regard to the bridge in the pipe of an ingot, we think that this is due, in many cases, not so much to the fact that the steel at the top of the ingot

freezes to the point where it is self-supporting and the metal sinks away as the ingot cools, as to the fact that support is given to the top shell by escaping gas. This is especially true of the bridge over the top of the pipe. The top surface chills and in a sense seals the gas that is escaping from the steel, and this gas, rising up through the metal, acts as a support before the shell itself becomes self-supporting. We are confirmed in this belief by the fact that in many cases the under side of the bridge is practically smooth, and has no crystals hanging to it. This effect is shown in Fig. 4.

Referring to Prof. Howe's recapitulation, the various points mentioned are discussed in his order:

"The pipe is shortened, though probably at the cost of increasing the degree of segregation:"

1. *By casting in wide ingots.* We understand from this that Prof. Howe thinks that casting in larger ingots would tend to decrease the length of the pipe. As far as our own steel is concerned, we do not find that this is the case. The depth of the pipe seems to increase with the size of the ingot, and as far as the depth of the pipe is concerned, it is practically the same in ingots of the same diameter, irrespective of the length. We are speaking now of a visible pipe. Fig. 5 shows a photograph of the section of a 10-in. and a 20-in. ingot, cast in the same group. The ingots were bottom-cast. It is true that the depth of the pipe in the 10-in. ingot is less than in the 20-in. ingot. As far as the center of the ingot below the pipe is concerned, which shows apparently solid when planed, etching shows a slight tearing apart, which we think is due to contraction-strains on the mushy center before solidifying, as suggested by Prof. Howe.

2. *By casting in molds of low conducting-power—i. e., lined with sand or clay—especially if pre-heated.* In a few cases we have made octagonal ingots in sand molds of the same size that we make in our regular practice in chilled molds. In each case the piping in the ingot cast in the sand mold was at least twice as deep as in the same sized ingot cast in the chilled mold. It may be that there is a greater virtual expansion in an ingot cast in a sand mold, owing to the fact that original cooling is not so rapid as in an iron mold, and this might account for the greater depth of the pipe.

"The pipe is shortened and the segregate raised:"

3. *By top-casting instead of bottom-casting.* In our practice we have found very little difference in the length of pipe whether the ingot is top- or bottom-cast. Our regular practice is to bottom-cast, but we have made a few top-cast ingots for experimental purposes. In the top-cast ingots which we made we found no appreciable difference in the pipe, and in the grade of steel we use there are practical reasons why bottom-casting is preferable to top-casting, and any slight difference that we might find in the length of the pipe would be more than counterbalanced by other points in favor of bottom-casting. Fig. 6 shows two small ingots, each weighing about 615 lb., which were cast in iron molds. *A* was top-poured and *B* bottom-poured. The ingots were not cast in the same heat, but the analyses given below correspond very closely:

	Combined C.	Si.	Phos.	Mn.	S.
A, . . .	0.675	0.280	0.044	0.68	0.050
B, . . .	0.645	0.285	0.045	0.63	0.053

It will be noticed that, as far as the depth of the pipe is concerned, there is very little difference in favor of the top-poured ingot, and this is doubtless due to the small sink-head, which was not used in bottom-pouring,

4. *By slow casting.* We believe Prof. Howe's reasoning with regard to slow casting is correct. In our practice the large groups help counterbalance the necessity of rather rapid pouring; assuming that we start pouring at the proper temperature, the steel should be got into the molds as rapidly as possible.

5. *By casting with the large end up instead of down.* Regarding the commercial feature of casting the ingot with the large end up, this has been our practice for the past 15 years. Our molds have solid bottoms, as shown in Fig. 7. We have been casting the output of three 50-ton furnaces in this type of mold, and have found no difficulty in operating. So little trouble has arisen that the plant has no ingot-extractor; the ingots are emptied out, and there is very rarely a sticker. This method of casting ingots was not adopted on account of any benefit that might be derived from shortening the pipe, but for other reasons. We have, however, made some bottom-cast ingots in molds with open bottoms, and these ingots are, of course,

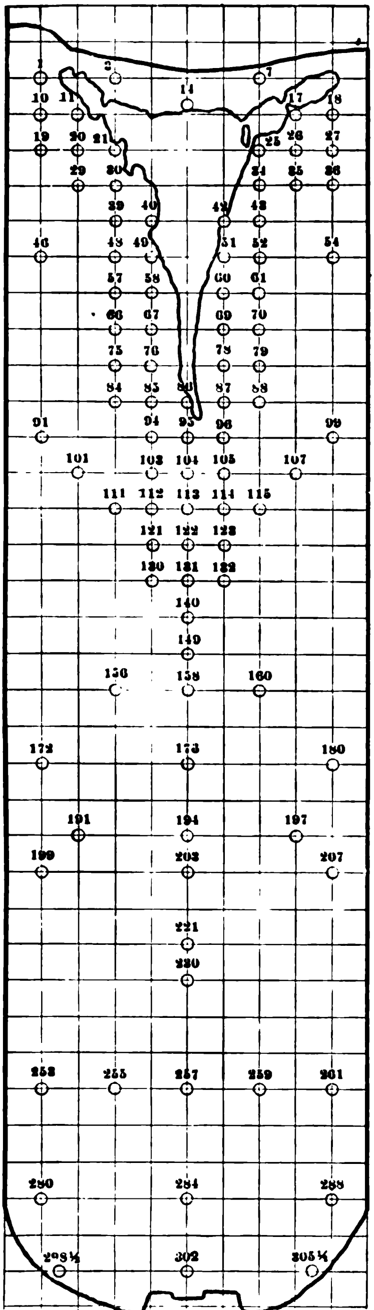


FIG. 3.—POINTS FROM WHICH DRILLINGS WERE TAKEN FOR ANALYSES OF TABLE I.

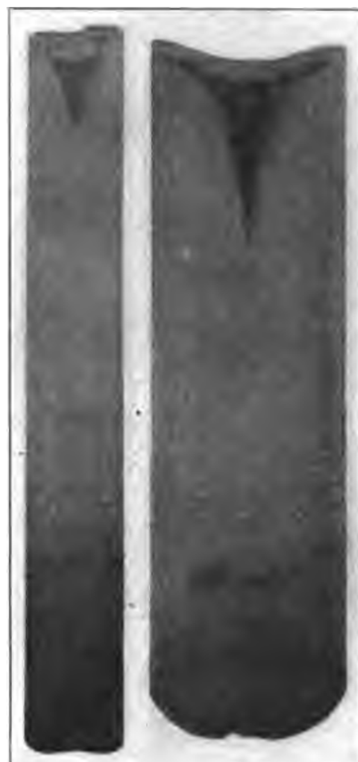


FIG. 5.—SECTIONS OF A 10-IN. AND A 20-IN. INGOT, CAST IN THE SAME GROUP, SHOWING EFFECT OF SIZE OF INGOT ON DEPTH OF PIPE.

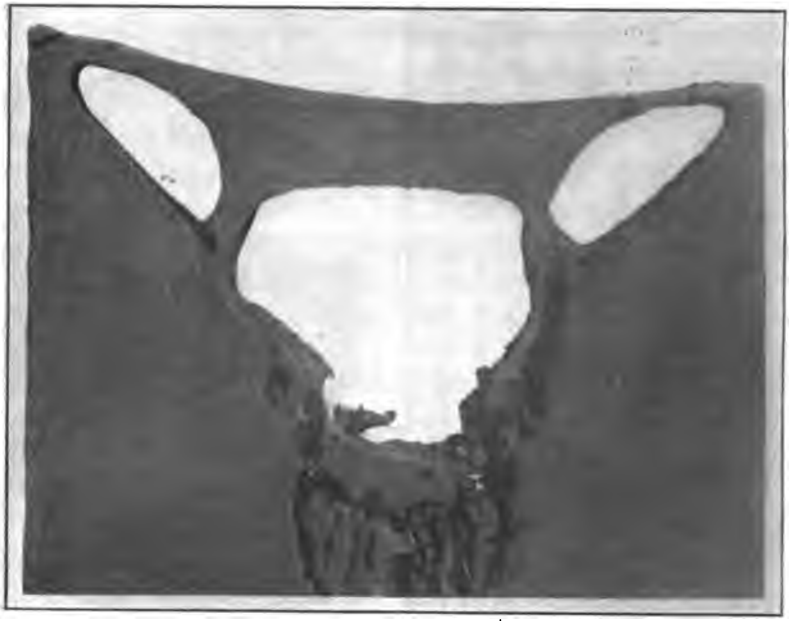
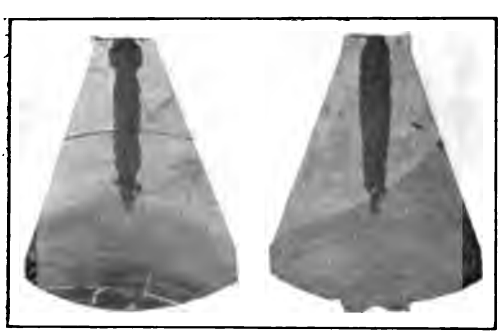


FIG. 4.—BRIDGES WITH SMOOTH UNDER-SIDE.



A, top-poured. *B*, bottom-poured.

FIG. 6.—SHOWING EFFECT OF TOP-POURING AND BOTTOM-POURING ON DEPTH OF PIPE.

FIG. 8.—DEPTH OF PIPE DECREASED BY CASTING WITH LARGE END UP.

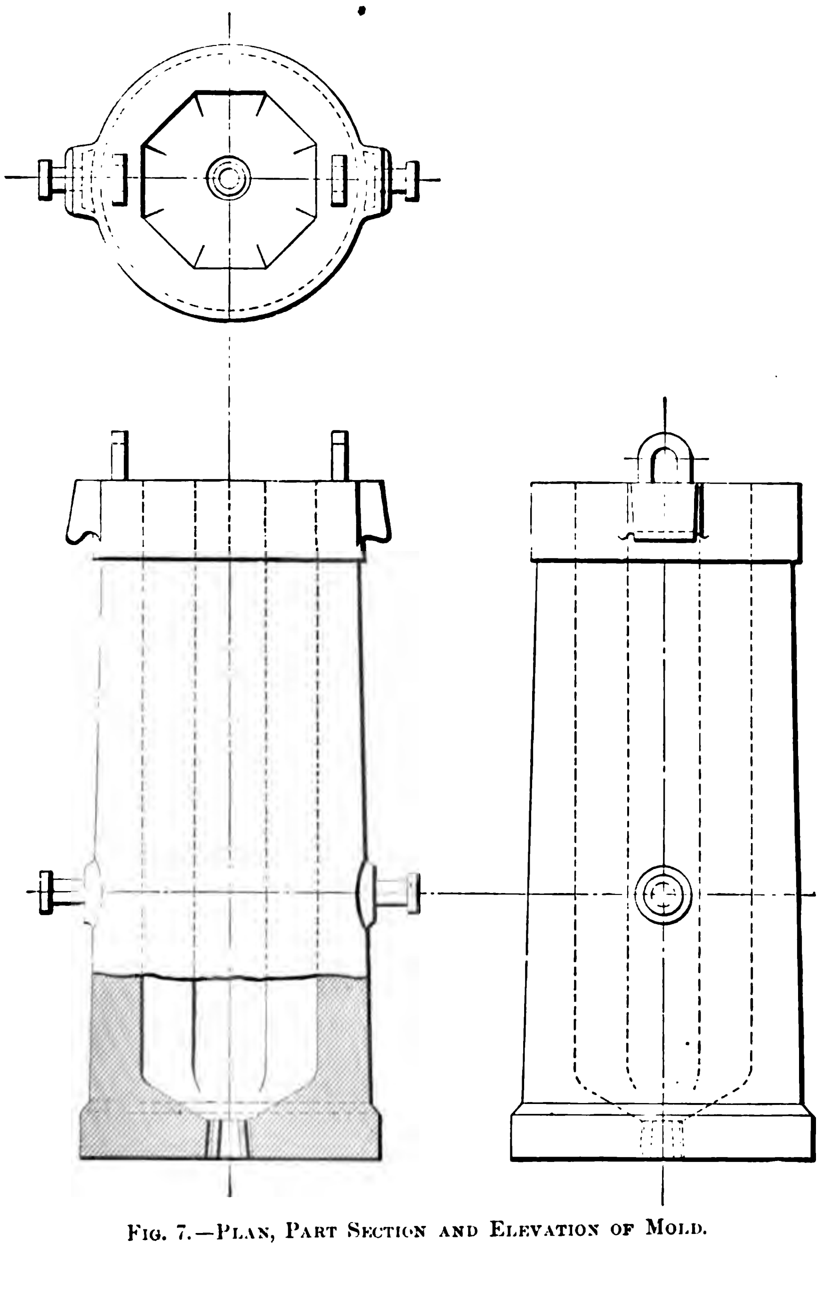


FIG. 7.—PLAN, PART SECTION AND ELEVATION OF MOLD.

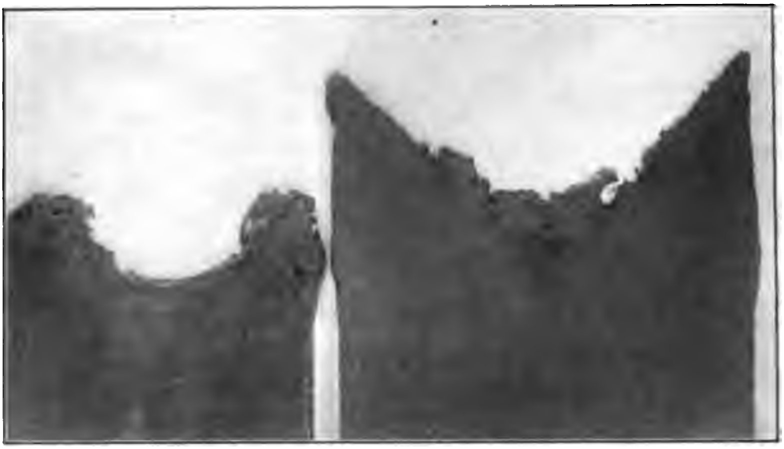


FIG. 9.—SECTIONS OF INGOTS, SHOWING THE EFFECT OF RETARDING THE COOLING OF THE TOP BY MEANS OF PLUMBAGO.

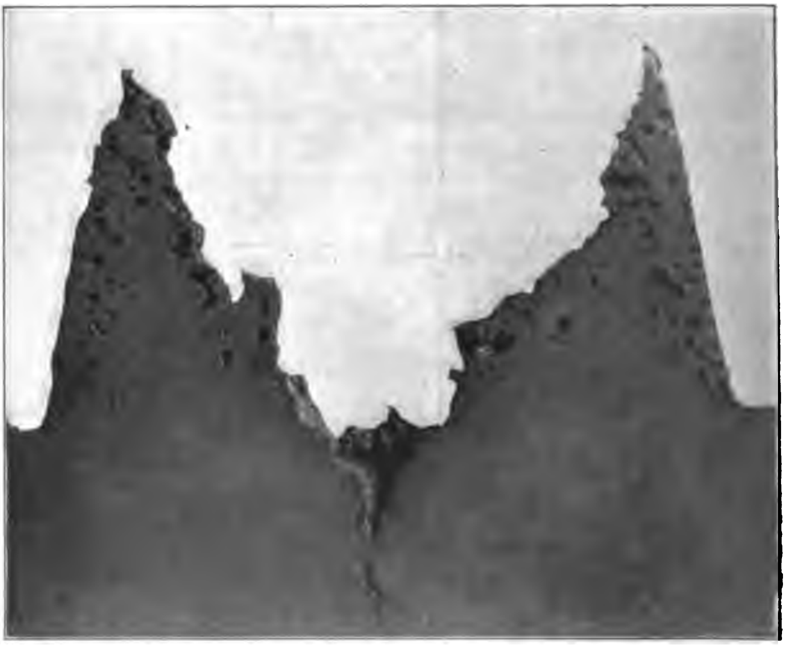


FIG. 10.—SECTION OF INGOT CAST IN A MOLD WITH A SAND LINING AROUND THE TOP, AND USING PLUMBAGO.

slightly smaller at the top than at the bottom. There was no commercial difference in the length of the pipe; in fact, if there was a difference it was not sufficient to attract attention. The large end of the mold in each case was about 0.75 in. larger in diameter than the small end. The question arises as to the amount of variation in diameter between the large end and the small end, which would make an appreciable difference in the pipe.

Fig. 6 (*B*) shows an ingot that was bottom-poured with small end up. Fig. 8 shows an ingot of the same dimensions cast in an iron mold, bottom-poured with large end up. In the latter case there is a very appreciable difference in the length of the pipe; the ingot cast with the large end up showing a much more shallow pipe than that cast with the small end up. These ingots were not from the same heat, but the analyses are almost identical.

6. *By retarding the cooling of the top by means of a sinking-head or otherwise.* As far as the shortening of the pipe is concerned, retarding of the cooling of the top of the ingot has a decided effect. As for segregation, we have not been able to detect much difference. Fig. 9 shows a section through the pipe of two ingots. Plumbago was put on the top of these ingots when the steel was within a short distance of the top of the mold.

Fig. 10 shows a section of the top of an ingot cast in a mold having a sand lining around the top of the mold, and using plumbago also.

7. *By permitting deep-seated blow-holes to form through adjusting the quantity of silicon and manganese or their equivalent.* In accordance with Brinell's experiments, blow-holes are not expected in steel of the analysis under discussion. We have made tires to specifications, however, that call for analysis that would permit the deep-seated blow-holes, but we cannot agree with Prof. Howe that this would be a good method of shortening the pipe. We certainly prefer the pipe to deep-seated blow-holes. We do not believe there can be any thorough welding up of blow-holes in this grade of steel; we know that in many cases there is not. This statement also applies to steel of the grade used for locomotive forgings. In the case of low steel, such as is used for plates, there are many cases of

blow-holes that are not welded. With blow-holes in tire-steel the tires naturally would wear shelly in service, and shelliness of tires seems to be the *bête noire* of the tire manufacturer. The prevailing practice 15 or 20 years ago was to make tires from short ingots, but a shelliness was developed due to piping and gas-holes; this source of shelliness, however, has been avoided by cropping the top or pipe portion of the ingot.

The tire manufacturers of to-day are again facing the problem of shelliness. An extensive series of investigations, covering a period of several years, the results of which were contained in a paper read by Mr. G. L. Norris before the Western Railway Club in Chicago last October, would indicate that this shelliness is largely due to conditions of service, combined with increased wheel-load, rather than to any inherent defects in the steel.

8. *By liquid compression.* We have had no actual experience with liquid compression.

"The degree of segregation is lessened:"

9. *By quieting the steel by adding aluminum or its equivalent.* There seems to be no question as to the degree of segregation being lessened by adding aluminum or its equivalent, but we desire to add to what Prof. Howe has said, that the amount of segregation also depends, in a large measure, on the condition of the bath and slag immediately before tapping.

10. *Probably by casting in small instead of in large ingots.* We believe that Prof. Howe has changed his opinion somewhat as to this point, and, as stated previously, this does not agree with results obtained by us.

11. *Casting at as low a temperature as practicable.*

13. *Casting slowly.* Would it not be better to say, casting at as low a temperature as advisable? Experience would tend to show that it is not advisable to cast at as low a temperature as is practicable. Admitting that casting at a low temperature and casting slowly are advisable, in practice the conditions, in a sense, oppose one another. We refer particularly to the casting of large heats. Starting at the proper temperature, the heat must be poured rapidly, and by group-casting we think we approach as nearly as practicable the two conditions.

12. *Casting in thick-walled iron molds.* That the degree of segregation may be lessened by casting in thick-walled iron

molds seems a reasonable conclusion, which our experience with long ingots apparently confirms. At the same time, it does not necessarily follow that the segregation will be lessened by casting in thick-walled iron molds, since small tire-ingots cast in such molds frequently segregate badly.

PROF. WILLIAM CAMPBELL, New York, N. Y.:—I have made a few notes on some of the things that the previous speakers have said. The first is about the shelling of tires. Some years ago there were submitted to me specimens of six tires of different manufacture, and I was asked to find out why they shelled, by the microscope. I cut out sections, and found in every case that the reason for the shelling was a very small film of oxide or parting, due to blow-holes. Mr. Kinkead remarked that they had taken some 0.40-carbon steel and by annealing had produced the same results as obtained in the Bethlehem tests on nickel-steel. Since Prof. Howe has been at Columbia we have been carrying out experiments on the annealing, etc., of steel all the way from 0.04 up to 2 per cent. of carbon, and we often find that we get really wonderful results. The temperature-limits are very small indeed. For instance, with a steel of, say, 0.50 carbon and 1 per cent. of manganese, the limit within which these results of strength with high ductility can be produced is about 50°, and seems to lie between the two critical points of heating: AC_1, a little above 700°, and AC_2, a little above 750°. That is the first factor. The second factor is the time. The time-element in annealing castings is very important indeed. We have some experiments under way under Prof. Howe's direction that show that ordinary heating and cooling of a piece $\frac{3}{8}$ in. square will not give refinement, but that it takes in some cases two or three hours for such a small piece. Mr. Huston suggested that we divide steel into mild, medium, and high, as well as into Bessemer, open-hearth, etc. Why not go a step further and grade it according to the analysis? The analysis of the whole steel series gives us a basis of comparison, whereas if we say that we are dealing with a piece of mild steel the manufacturers of tubes, boiler-plate, etc., understand one thing, whereas the structural engineer understands quite another thing. Recently I obtained what I was told was mild steel, and, under the

microscope, it looked to be 0.40 carbon, and the analysis showed that it was. Yet the manufacturer that made that steel classified it as mild steel.

It has been said that work at a high temperature does not affect the structure. This is a fallacy that has been accepted for a long time. Many of us have the idea that the finishing-temperature is the main factor determining structure. We had the idea that we were finishing our steel rails at near the critical point. For the last two summers I have been working at this subject with pyrometers, and I have found that these temperatures for finishing vary all the way from 950° to 1,100° C.

When I so reported I was laughed at, but the pyrometer gives these readings, and when I asked one of the inspectors how he got his temperature, he said, "The rail runs down to the cutting-saw and there a piece of about a foot long is cut from the waste end, a workman puts it in a bucket of water and we read the rise in the temperature of the water, and I am finishing at 850°." With that kind of a pyrometer you can get a great deal lower than 850°. I do not think there is any question that the finishing-temperature is not the prime factor determining grain-size. I think the amount of reduction in the rolls has a great deal to do with the final product.

We have heard that in the case of faulty material, such as bad tires and rails, chemical and microscopical analyses indicate nothing. I agree that the former alone is often useless, but the two together, in nine cases out of ten, will solve the difficulty.

Again, it has been said that if you take boiler-plate and pull a piece that has been cut longitudinally, and another piece that has been cut across, you will get different results; also that iron pulled across the grain breaks more easily; as if the grain of the iron had anything to do with it. It is not the grain, it is the slag. The grains are all the same. With good wrought-iron the grains measure the same, whether you take them across or through; but it is the slag-line that gives you the weakness with pieces cut across. In the same way with low-carbon steel, on cutting a section parallel to the direction of rolling, the structure is often found to be decidedly banded. The ferrite and pearlite bands are quite distinct, due to segre-

gation, and etching shows up light and dark streaks. In the ferrite bands—*i.e.*, those poor in carbon—we find much or most of the manganese sulphide and silicates, drawn out in elongated masses and threads, and here also the phosphorus segregates. Hence, a section parallel to the direction of rolling will prove much stronger and more ductile than one cut across. A similar state of affairs is found in rail-steel, the effects of manganese sulphide and silicates being even more marked at times.

With regard to the two different types of ingot-structure, there is a polished ingot at Columbia which is an excellent example. For a depth of 0.75 in. the metal is composed of comparatively small regular grains, beyond which it is built up of long pine-tree crystals perpendicular to the sides of the mold.

HENRY D. HIBBARD, New York, N. Y. (communication to the Secretary*):—These remarks refer, except when stated otherwise, only to the harder grades of steel, and not to what is known as soft steel, in which the only thing which classifies it under the name of steel is the fact that it is made by a fusion process.

These harder steels are or should be made by what I have termed the "solution" process of steel-making, in which the gases are kept in solution during solidification as completely as practicable, as distinguished from the "evolution" process practiced in making soft steels, in which the gases are encouraged to evolve freely from the metal while it is freezing.

Many of the points for procedure in the manufacture of steel which are laid down and emphasized have for their object the cure of ills which should not exist, and such points are likely to be considered especially essential by some one who has found them or some of them to have benefited steel made by his established methods.

Broadly speaking, the better the steel is made the more it will pipe. Whether or not proper treatment before casting affects or reduces the central segregation, I do not know, but the local segregation resulting in hard spots near the outer surface is undoubtedly due to bad practice somewhere before the steel reaches the mold. The condition before casting must

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* Received Mar. 3, 1908.

be right within narrow limits, as regards temperature and degree of oxidation as well as composition, otherwise the results cannot be good.

A blow-hole, in a way, is the result of local segregation of gases, and is often, if not always, accompanied by segregation of other impurities as well, particularly carbon. In forgings made direct from the ingot and with insufficient work, and having a large number of hard spots, I have seen close beside each hard spot the remains of a blow-hole which had not been wholly closed up by the forging-process.

Regarding the two supposititious methods of solidification of steel ingots described by Prof. Howe, the one assuming the formation of "pine-tree" crystals is attractive, since if they are large it gives a reasonable explanation of the local segregation which results in numerous hard spots near the outer skin of the ingot by entangling or inclosing portions of the liquid steel, which is in condition for segregating as it freezes. Such crystals may occur during solidification in certain grades of steel made in certain ways (probably not the best), but they cannot be assumed to be formed always, especially in the soft grades. It seems probable that they will be found, if at all, only in the harder grades and in those that are not well made.

Granting that continuity of structure is essential in the best steel ingots, the ideal procedure to make them is to start with suitable plant and materials, make the steel properly as to physical and chemical conditions before casting, and reduce or obliterate the pipe and the central segregation by compressing the ingot laterally while the interior is still fluid. It is assumed, of course, that all details favoring these broad divisions of the operations will be adopted. The possibilities of lateral compression have not as yet been fully realized.

To speak of the entrained silica, silicates, and oxides in steel as slag is, in a sense, misleading, as while they may be the same as some of the slag-ingredients in composition, and should properly find their way into the slag, they are not wholly derived from the slag. To call them slag is much like calling springs along the banks, the water from which flows into a river, the river itself.

To remove the entrained oxidation-products from steel, agitation is more efficient than time. The individual particles of

oxides and silicates are so minute that gravity alone does not free the steel of them much faster than it clears rily or oily water. The operation of removing them is thought to be like this: Assuming that they are fusible at the temperature of the molten steel, each particle will, when it touches another, stick to it, forming a larger particle, which again will unite with another, and this operation continues until the resulting particle becomes large enough to float to the top and merge into the slag. This will be very slow if effected by gravity alone. By stirring, the time required for the elimination of these products to any given degree may be reduced to a fraction of that required by the action of gravity alone. The agitation which takes place in the molds in soft steel made by the evolution-method, due to the escaping gases, is very efficacious to the end in question.

If, however, the oxides or silicates are infusible at the temperature of the steel, so that they do not "wet" each other and unite when they touch, there will be imperfect elimination of them, limited almost wholly to that effected by the cleansing absorption by the molten slag of such particles as come in contact with it, and the steel will be red-short. Silica alone, or magnetic oxide of iron alone, undoubtedly acts in the manner described, and probably largely so when they exist together in steel. Silicate of manganese, however, is the great agent for the removal of the entrained oxidation-products by fluxing them, and this is formed from the final additions and entrained silica.

In the open-hearth furnace the charge may be retained until it shows the proper qualities for casting. The oxidizing conditions may be reduced by appropriate treatment to almost any degree, so that the metal approximates very closely to crucible and electric-furnace steel. The temperature also may be brought to the desired degree by raising or lowering it as needed.

This, more than anything else, except perhaps the increased yield, will bring to pass the fulfillment of the often-quoted prophecy about the open-hearth process attending the funeral of the Bessemer process, and gives the former a great advantage over the latter process for making certain grades of steel, if not all. In the Bessemer process both the degree of oxida-

tion and the casting-temperature must "be caught on the fly," as it were, and after the converter is turned down but little can be done to change either of these fundamental conditions.

HENRY M. HOWE, New York, N. Y. (communication to the Secretary *):—Dr. Dudley, in speaking of the genesis of the pipe (p. 397), has "never found an instance in which the metal had separated after being firm." But how can he know this? On pp. 202 and 214 of my paper I gave my reasons for inferring from the shape and structure of certain parts of certain pipes, that those parts had opened in metal already firm. Does Dr. Dudley not find that shape and structure, or does he not agree with my reasoning?

Mr. Stevenson seems to imagine several differences of opinion between himself and me which either do not exist or are immaterial.

As to the shape of the molten lake during the solidification of the ingot, the difference between Mr. Stevenson's idea and mine seems to me wholly immaterial. The bottom of the lake will of course be nearly flat at first, as he sketched it. The pointing which I sketched would come much later. At what particular moment it comes is not material to anything in my discussion, so far as I see; nor is it material that it should come at any time.

Nor have I any objection to supposing that imprisoned gases may aid in the support of the bridges. This idea does not conflict with my own in the least. The bridges cannot be supported by gases until it is a solid bridge. When solid its own rigidity is surely competent to give it some support. If gas aids this rigidity, so much the better.

Mr. Stevenson's solidification (p. 110) is "invariably" of the land-locking type. How does he know?

Mr. Stevenson agrees with me as to the effect of (1) casting with the large end up, (2) top-casting, (3) sink-head, (4) slow pouring, and (5) aluminum. Dr. Dudley agrees with me in the first and last of these, and does not disagree, so far as I see, in any respect. That he agrees as to slow pouring is to be inferred from his saying that the pipe is shortened by the use of a small nozzle. Mr. Stevenson differs with me as re-

* Received May 5, 1908.

gards the effect of the width of ingot and the rate of cooling (use of sand *vs.* iron molds) on the depth of the pipe. There are so many variables that unless great pains are taken the effect of the one we have in mind may easily be masked by that of others. The use of a baked sand mold instead of an iron one may so far restrain the evolution of gas and thereby the formation of blow-holes, and thereby increase the depth of the pipe, as in this indirect way to outweigh its direct effect of shortening the pipe by increasing sagging. In one direct series of experiment of which I know, the depth of the pipe actually decreased with the width of the ingot, as my prediction calls for. Beyond this, in a great number of very narrow ingots within my own knowledge, the pipe has reached very much deeper than it would have gone had the ingots been wider. But there may be other influences in addition to those which I have considered which under certain conditions may outweigh mine.

It is not with regard to piping and segregation, but with regard to the use of the English language, that Mr. Stevenson differs with me as to whether the casting-temperature should lie "as low as practicable," or "as low as advisable." I see no serious objection to substituting "advisable" for "practicable," though to me "practicable" seems to convey more clearly the idea of being as low as is permitted by the attendant conditions, such as the need of running freely through the runners, not leaving a heavy ladle-skull, etc. But is this sort of criticism quite worth while?

I take issue very squarely with Mr. Stevenson as regards the supposed conflict between low casting-temperature and slow pouring. I see no conflict. To pour slowly and yet cool, merely means to pour into many molds at the same time, exactly what Mr. Stevenson himself is doing, for this among other purposes is bottom or, rather, group-pouring.

As regards the size of ingots, Mr. Stevenson and I agree, as my paper presented in the morning before his remarks clearly shows. If anybody proved by abundant direct experiments, before the publication of my paper in the *Engineering and Mining Journal*, Nov. 30, 1907, p. 1011, that ingot-size and rate of cooling have but slight effect on the degree of segregation, I do not know it.

Mr. Stevenson seems to agree with me that deep-seated blowholes will lessen the pipe. I certainly agree with him that they should not be tolerated in high-carbon tire-steel, because they will not weld, and, unwelded, will be disastrous by causing shelliness.' That remedy is of value in many, but certainly not in all cases.

In short, though Mr. Stevenson might lead some to suppose that we differ in nearly every respect, in point of fact our differences are very slight.

Prof. Campbell is right in what he says about finishing-temperature. It is only on the assumption that by "finishing-temperature" we mean that at which distortion severe enough to unequiaxe the existing grain-size so far as to cause a new grain to form corresponding in size to the then existing temperature, that the laws between finishing-temperature and quality can be supposed to be true. This all of us should have had, and many of us have had, in mind; but Prof. Campbell does well to call our attention clearly to the matter.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

The Work of the Testing Department of the Watertown Arsenal, in Its Relation to the Metallurgy of Steel.

BY JAMES E. HOWARD, WATERTOWN, MASS.

A Discussion of the Paper of James E. Howard, presented at the New York Meeting, February, 1908, and printed in *Bi-Monthly Bulletin*, No. 20, March, 1908, pp. 151 to 156.

JAMES E. HOWARD, Watertown, Mass.:—In connection with this paper, it is the desire of the Watertown laboratory to receive suggestions as to the lines of work and the particular direction along which the examination of the ingot-metal should proceed, and any suggestions so offered will be noted with care, and the tests conducted so as to embrace such features as it is thought desirable to have investigated.

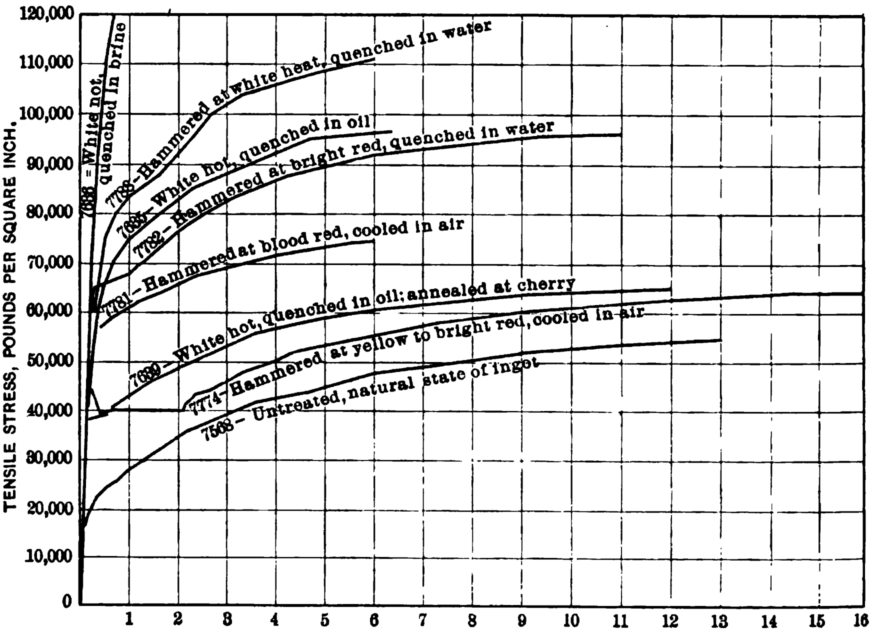
To me the question of structural continuity seems of paramount importance in those investigations of the properties of steel which begin at the ingot. The modification of the tensile properties may easily be accomplished in the mechanical treatment which succeeds the ingot state of the metal, as is illustrated in Fig. 1, showing the tensile properties found in low-carbon steel.

It will afford us satisfaction to have some specific or general procedure for conducting the test indorsed by the members of the Institute. The work will necessarily take a definite direction, and a number of different lines have already been suggested. The question of the manufacture of steel rails, which has attracted as much attention as any other subject, is now being studied at the Watertown Arsenal.

R. W. MAHON, New York, N. Y. (communication to the Secretary*):—An investigation of ingot-structure and the causes leading thereto, and of the effects in the rail or other finished shape following the various observed features of ingot-structure, would be in effect a study of steel metallurgy. If such an investigation is to be carried out in an exhaustive

* Received Feb. 12, 1908.

manner, I think that, before proceeding to any study of finished material, the investigation should begin with a study of the ingot. Besides this possibly more scientific and fundamental way of proceeding, I wish to suggest that there are many problems the investigation of which could be carried out, principally by a study of finished material. This investigation might proceed simultaneously with the proposed more elaborate scheme, and thus shorten the road to the practical



Chemical Composition: Carbon, 0.20; Manganese, 0.58; Silicon, 0.015; Phosphorus, 0.017.

FIG. 1.—RANGE IN TENSILE PROPERTIES OF STEEL FROM THE SAME INGOT, DUE TO HEAT AND MECHANICAL TREATMENT.

results desired by the users of steel. I propose the following subjects, which could well form a part of the general program:

1. *Tires.*—The cause of the shelling of the tread. What precautions during the process of manufacture will prevent shelling in service? What is the best composition to prevent shelling?

A peculiar thing I have noticed for years is that the trailing tires and the tires used on tenders are the ones which develop

those shelling-defects the most frequently. Furthermore, it is new tires which fail from shelling, not those which have been turned after service. This fact suggests the idea that shelling may have its primary cause in unusually columnar or unsound exterior ingot-surface.

This being an application of Dr. P. H. Dudley's idea, that rail-heads sometimes fail from this cause, I do not think that the cause of the failure of the trailing-tires is the great weight on them, because the weight is no greater than it is on the driving-wheel tires.

2. *Steel Castings.*—The best results in annealing steel castings are obtained when they are heated to between 700° and 800° or possibly 850° C. What is the best temperature at which to remove steel castings from the furnace in which they are being annealed?

Is the range from 700° to 850° C. the best annealing temperature for vanadium-steel castings?

What is the best temperature at which to remove vanadium-steel castings from the furnace in which they are being annealed?

A manufacturer of steel castings in a large way recently told me of certain small frames that he was trying to make. He could not make them according to the specifications, and finally the superintendent went to the office of the works to say that he would have to give it up. There was a heat in the furnace, and during his absence the foreman, in exasperation, took hold of the castings and threw them on the floor. A few days afterwards the steel was noticed to be very elastic. Test-pieces were prepared from it, and the material was found to meet the specifications perfectly. The superintendent corrected his first statement and said that he could make them. Now that was only a question as to the temperature at which that particular steel casting should be removed from the furnace in order to anneal it properly.

Some people are skeptical of obtaining the same degree of homogeneity in plates rolled from small ingots and in those rolled from slabs after the proper discard has been made. As this is a matter of fundamental importance to all steam-users, I propose an additional subject for investigation:

3. *Steel Plate.*—A thorough investigation of the question of the homogeneity of plates rolled from the ingot and plates rolled from the slab.

One of the most vitally important materials purchased by the railroads is axles. While in making other steel products for the roads there is some degree of uniformity in methods of procedure among manufacturers, in making axles the contrary is true. Axles are partly shaped in rolls and then rapidly forged at one heat, not being subsequently annealed. They are made entirely by rolling without subsequent forging. They are forged at two heats, by alternately heating the two ends, in each case heating more than one-half of the length of the axle, and not subsequently annealed. They are forged and then annealed by the Coffin process. They are forged and annealed in an annealing-furnace, being held in the furnace until cold. Sometimes axles after this last operation are of unsatisfactory character, due to lack of care or skill, and the annealing is repeated. So that a lack of uniformity in the process may truly be said to exist. In consequence of these facts I propose that two additional subjects be added to the investigation. Of course, this would not be altogether an investigation into the unknown, but in some directions a striking demonstration of well-known facts.

1. What is the best method of shaping and annealing steel axles; and what is the effect upon the value of the finished product of each of the modifications at present in considerable use in this country? and

2. What is the effect of repeated annealing?

A. A. Stevenson, Burnham, Pa.:—There is one very important point that I have not heard mentioned by Mr. Howard, and that is the question of the minimum amount of work for maximum effect. Is this not a question well worth investigation? Is it not possible there are cases where there is too much work put upon steel, and could not as good or better results be obtained by a smaller amount of work?

Now as to the question as to what led up to the meeting which was held in New York, Sept. 24, 1907: An appropriation was made by the government some time ago for use in experimental work at Watertown Arsenal. Mr. William R. Webster and Prof. Marburg were appointed by the government to act in connection with the Watertown Arsenal authorities in an advisory capacity.

Unless I am mistaken, the meeting was largely the result of some missionary work on the part of Mr. Webster and Prof. Marburg. Letters were written to various engineers, railroad men, and manufacturers. The meeting itself was purely informal. The object of the meeting was to talk over the work that might be done with the appropriation, and Major Ruggles and Mr. Howard were anxious to obtain suggestions as to the lines of work which might be followed that would be of greatest use to the engineering profession, and to ascertain whether contributions of material for experimental purposes would be made.

A record was kept of the proceedings, but the idea at that time was not to have this record published. The meeting itself was very interesting. There was a free expression of opinion, and numerous suggestions were made. There seemed to be a little feeling on the part of some of the speakers that the work to be done was in a sense superfluous. The question was asked, "Does this mean that we will shut down our own laboratories?" The majority felt that this was not the idea at all, and that the work at Watertown Arsenal would not take the place of the work in our own laboratories; the experiments to be conducted there would not take the place of those conducted in our own shops, but rather would supplement them.

I think manufacturers should assist in every way the work that has been started by this appropriation. Several steelmakers have already made contributions of material to Watertown Arsenal and work is now in progress. None of the results are yet ready for publication.

J. A. KINKEAD, Schenectady, N. Y.:—I made a comparative test of longitudinal and transverse sections of steel forgings recently, with the result that the transverse test gave 13 per cent. elongation and 11 per cent. reduction, while the longitudinal test gave 27 per cent. elongation and 30 per cent. reduction.

In regard to steel castings, a few years ago the Bethlehem Steel Co. reported some very remarkable tests of nickel-steel; and one of our steel-casting friends took his ordinary product and by proper heat-treatment duplicated the results in every respect; in other words, where they had a 0.40-carbon nickel-

steel he used 0.40-carbon cast-steel, and by proper annealing the same elongation and reduction of area were obtained.

In regard to transverse tests that have been made on pieces of rails, we meet that all the time in boiler- and fire-box plate, and in many cases the transverse tests equal the longitudinal. In some instances we have cut four sets of tests, and the tranverse tests have averaged as good as the longitudinal. Of course, the longitudinal tests were affected to some extent by the rolling of the shell, which would affect the transverse test to a less extent. It is understood that all fire-box steel is cross-rolled.

I have recently had a case of defective steel in which the tensile tests were satisfactory in every way, yet the castings had more or less cracks and blow-holes that could not be accounted for by the steel foundry. On investigation it was shown that the charge for the open-hearth furnace was not what it should have been.

On the subject of billets, I could get any quantity of exhibits of that kind. In using up stock billets it is necessary to cut many to the right length in cold saws, which readily shows piped centers.

Charles L. Huston, Coatesville, Pa.:—Prof. Howard's point is well taken, in his statement that a general knowledge of the conditions of the metal in the ingot is highly essential to the study of the material and its fitness for use after having been worked into shape.

Variation in yield-point, elongation and reduction of area, however, may be produced by the manner of heating and manipulation in the rolls, as also by the proportioning of the test-pieces.

I would suggest that for the study of the ingot-structure, in addition to the proposed division by grades, such as open-hearth, Bessemer, and crucible steels, they should be carefully divided into mild steels, steels of medium carbon, and steels of high carbon, and also the different alloy-steels, on account of the very different action of these different steels in the process of cooling and solidification from the molten state, which action largely affects the question of chemical uniformity as well as of structural continuity.

In the proposed observance of working-temperature, number of pieces, etc., I believe that little effect will be observed in the final product from work done at the higher temperatures above the point of recalescence, as the work done at these temperatures does not permanently affect the structure of the steel to any great degree.

I apprehend it will be found that the best and most practical results will be gained by ordinary "horse-sense" methods, carried out in patient, painstaking study of all stages of the processes of manufacture and manipulation and their effect on the final product.

I am glad, indeed, that this subject is now being taken up vigorously by investigators of steel; and while it means a lot of trouble and probably will result through time in disagreement between the different "Doctors," yet I think ultimately it must result in a better appreciation of the conditions we have to deal with in steel, and in obtaining a more practical and satisfactory basis of specifications and inspection.

I want to encourage the use of a softer range of steel for boiler and structural work, as I believe that many of the specifications now in use run to the high limit too much and endanger the use of brittle steel, especially as in plates the portions usually tested are not the hardest portion of the steel in the plate, and I believe that where softer steels are used a closer factor of safety would be warranted.

I believe that, in practice, better results would be derived if, instead of allowing pressures or stresses in proportion to the actual minimum tensile strength obtained, which introduces a temptation to use just as hard steel as can be passed through under the inspection and thus avoid the use of greater thickness in order to carry heavier stresses, the thing were gotten at in the reverse way by establishing the unit stresses in the finished structure and then specifying the range of tensile strength of steel which will be allowed to stand these unit stresses; for instance, given a unit stress of 12,000 lb. per sq. in., permit the use of steel anywhere between 50,000 and 60,000 lb. per sq. in., provided it has a ductility of 1,500,000 divided by the tensile strength in pounds, thus using the combination of tensile strength and ductility to determine the maximum unit stress, instead of the tensile strength alone. This would encourage

the use of softer steels for the same work, and I believe would result in much greater safety to the traveling public, who intrust themselves to the skill and fidelity of the engineers and manufacturers responsible for the structure which carries them.

F. N. SPELLER, Pittsburg, Pa.:—Regarding the matter dealt with in Mr. Howard's paper, I am inclined to agree with Mr. Stevenson that all inquiries into the origin of defects in steel must go back further than the ingot, starting with the metal from the blast-furnace and giving due regard to its composition, treatment in refining, ladle-reactions, deoxidization, etc. For example, in the manufacture of soft welding steel we may add sufficient ferromanganese to deoxidize the metal, and, by a good reaction in the ladle, flush out the steel so that the oxides formed are practically all absorbed by the slag. A slight change in the relative proportions of silicon, manganese or other elements in the pig-iron may alter conditions entirely, giving a ladle-cinder incapable of absorbing the products of deoxidation from the steel, and resulting in more or less trouble all the way to the finished product. Yet, in this case, the chemical composition and structure of the ingot may be normal; the steel, however, is liable to develop defects under subsequent mechanical treatment.

The fact that lines of weakness are developed under stresses applied transversely to the direction of rolling does not necessarily prove the metal to have been structurally unsound in the ingot; to my mind, it is more often evidence of lack of lateral work. We have made a close study of soft Bessemer steel used in the manufacture of welded pipe, having, I presume, one of the best opportunities for studying this class of steel, since our practice lies in the manufacture of this steel exclusively. It has been our experience that most, if not all, structural defects in ingots are overcome by proper treatment in rolling; however, we are open to any advantages which the carefully-planned tests outlined in Mr. Howard's paper offer in the way of learning more about steel in general, and to this end will be glad to co-operate with the Watertown Arsenal Committee so far as possible.

E. H. MCHENRY, New Haven, Conn. (communication to the

Secretary*):—I have taken great interest in this matter at all times, but in reading recent discussions on the subject, I find that the suggestions and recommendations which I would wish to present have been anticipated almost completely, and I do not feel that I can add information of value at present.

I wish to suggest, however, that micro-photographs from the crystalline structure be added to rail-specifications, preferably in double form, showing average requirements and the extreme limits in the direction of coarse crystallization. Four or five years ago I secured the introduction of such matter in the specifications of the Canadian Pacific Railway, in a contract awarded to the Pennsylvania Steel Co. for high-carbon rails, rolled at the Sparrow's Point works.

I also suggest the determination of the value of carbon in terms of structural stiffness, considering the rail as a girder, as I have long believed that a relatively light high-carbon rail, with the same deflection as a heavier section low-carbon rail, is a more economical method of securing the requisite strength. The results could be tabulated, showing equivalents in rail-sections and carbon-percentage at intersection of columns.

The same considerations apply in much greater measure to angle-bars, as conditions do not readily permit the addition of metal at any point excepting the neutral axis, where it is least effective.

I also suggest the addition of an abrasion-test to determine the loss of weight and penetration, which may possibly be best attained by noting the effect of revolutions of a hardened steel bar applied to the rail under high pressures.

I believe these last two points are particularly worthy of consideration, as the two principal and almost the only functions of the rail are those of a girder and of a wearing-surface. To the best of my knowledge, modern specifications make no provision for determining either of these important points, apart from the somewhat doubtful results obtained from the drop-test, which is primarily for the purpose of determining brittleness.

P. H. Dudley, New York, N. Y. (communication to the Secretary*):—Referring to the series of tests on railroad mate-

* Received Mar. 31, 1908, through the courtesy of William R. Webster, Philadelphia, Pa.

rial, which are to be made at the Watertown Arsenal, I can assure you that the New York Central & Hudson River Railroad Co. will be glad to co-operate and take part in furnishing material for tests of different kinds, and also to provide opportunities for service-tests.

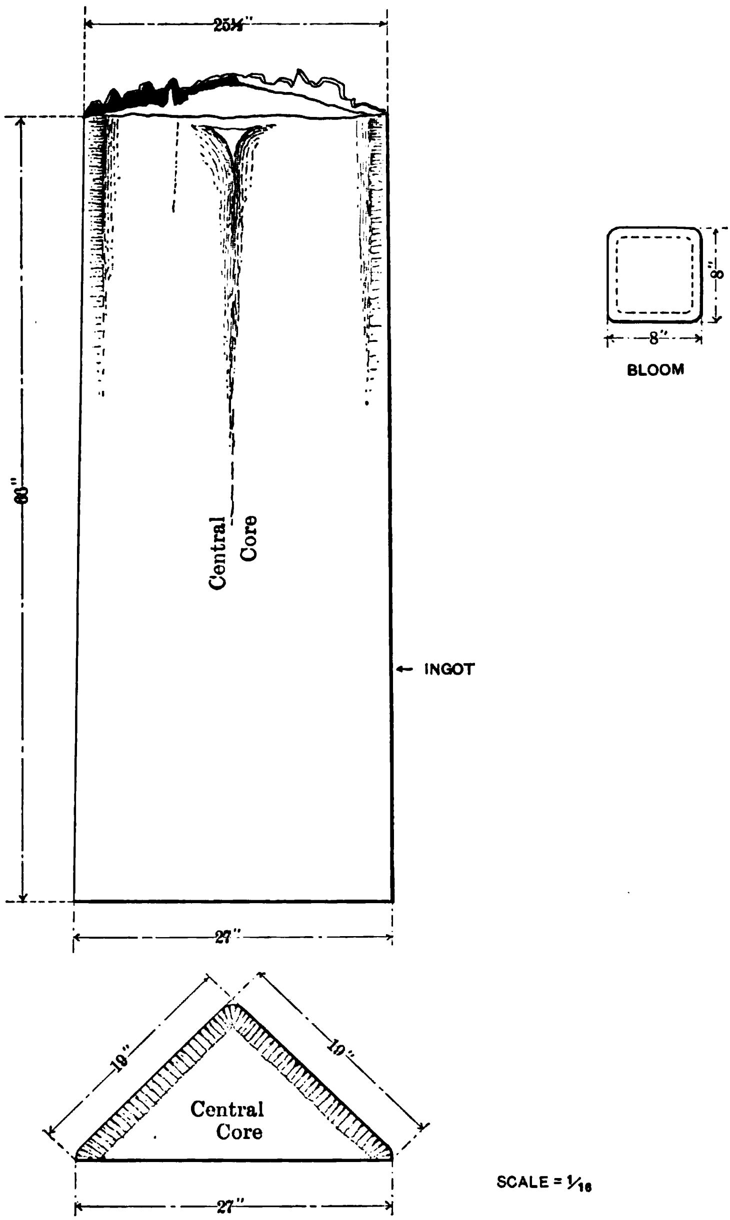
Personally, I have furnished for the past two decades old and new rails for testing to the U. S. Arsenal at Watertown (see Reports, Ordnance Department, U. S. A.).

Conferring with Mr. Mahon, the sketch, Fig. 2, showing the ingot-structure after casting and cooling for rails, is offered as a suggestion for one line of investigation.

Ingot-Structure.—The steel when cold in the ingot will show more of a shrinkage-cavity than when it goes direct to the heating-furnace, and does not cool down before passing through the blooming-train. The columnar structure in the corner of the ingots should be examined for entrained gas, slag, sponginess, and the cavity near the top. The entrained slag in the corner of the ingots often develops as defects in the corner of the rails. The elongated columnar structure and central core should be examined from the bottom to the top of the ingot for traces of oxides and slag, and their effects upon the soundness of the metal. The center of the ingot to be examined for pipe or sponginess its entire length, and for the amount of the portion of the ingot which is unsound. The structure of the entire ingot would show the character of the metal, and it should be tested for tensile, shearing, and compression strength in several places, particularly where segregation occurs of any of the metalloids.

Transverse tests should be made of the junction of the columnar structure with that of the central core. The blooms would show the ingot-structure reduced before it cooled, and should be examined for soundness and solidity by the same character of tests as the ingot. The specimens should be taken from parts which correspond as nearly as possible to their former location in the ingot. Rolling the metal to the bloom would show the effect of work, and whether the cavities were closed or elongated, and the degree of importance to be attached to the effect upon the steel.

Rails from an ingot of the same heat, numbered from top to bottom, would show the relative solidity and soundness of metal



The central cavity near top is a trace only in fair-setting steel, though of magnitude in poor metal.

The etched transverse section of the bloom indicates the zone of vertical blow-holes between the columnar structure and the central core.

FIG. 2.—PLAN AND VERTICAL SECTION OF INGOT, CUT DIAGONALLY FROM CORNER TO CORNER, INDICATING THE COLUMNAR STRUCTURE.

Segregated metal, split head, sound at ends. Carbon in bearing-surface, 0.45; center of head, 0.65; phosphorus, 0.16. Etched 30 minutes.

FIG. 3.—100-LB. SECTION L. S. Co., 1905.

Fourth Ave. Tunnel, 3 years and 9 months, lost 15 lb. per yd. Porous steel, flows and wears rapidly. Etched 30 minutes.

FIG. 4.—WORN 100-LB. SECTION C. Co., 1900.

of the finished section, and the increase of physical properties by work and heat-treatment of manufacture.

The ingot, bloom, and rails should all be from ingots from the same heat.

The examination of the properties of the metal in the ingot, bloom, and rail should be in the direction of the length of the ingot, and also at right angles.

The cubic or elasticity of volume of the metal in the head is of even more importance than the linear elasticity, and should have extensive investigation, for we have little information on this important feature.

In case of failure in compressive tests note should be made of any types of defects in the metal which conduce to a reduction of the factors of strength.

The metal in the rail-section should be examined in the head, web, and base in relation to its functions as a girder, primarily, as to the capacity of the metal in the bearing-surface to receive and sustain the wheel-contacts without undue destructive deformation of the steel by flow, or of the rail-head as a part of the section. The forward progressive destructive action of the moving-wheel contacts bears some relation to the wheel-load effects, area of contact, and the usual physical properties of the steel, its resistance to repetition of loads, and soundness of the metal.

The slag, gas, and impurities entrained in steel are not uniformly distributed, but localized, by many conditions in the cooling ingot, and manufacture, which are subsequently to be investigated.

Another series of investigations which can be instituted at once is the deformation of the section in inch lengths of the rails cut off in the web just under the fillets.

A force applied in the center of the head by flat and curved surfaces, to represent a wheel-tread, should be used, and the pressures first should have some reference to the wheel-loads, but eventually they should be carried to such pressures as will cause the metal to flow and even shear. The action of the wheel-treads in laterally spreading the metal in the bearing-surface of the head cannot be definitely reproduced in such tests, for they are the application of a great number of loads, and the heads of the rails split or are deformed by detailed fractures.

The ends of the sections should be polished and etched, to indicate the homogeneity and soundness of the metal, before the pressure is applied. They should also be photographed for reference. Then, after destructive pressures are applied, they should be re-photographed to show the disturbance of the metal.

Plungers should be designed to only touch upon the outer corners of the bearing-surface, and see what force is required to crush, split or shear the metal through the sides of the head.

There would be several types of failures in the tests, according to the position of the portion of the rail in the ingot as effected by segregation and slag-inclusions, unsoundness of metal, and formation of the metal in the passes of the rail-trains.

Similar tests could be made upon the base, using the entire section and applying the pressure to the head, and noting what was required to deform or split the base.

Many other tests upon the inch sections are required, which are being formulated for tests in case they are not incorporated in the proposed program.

There must be sufficient metal for tests of adjacent sections, for solidity and soundness of the metal. Some of these tests could be made at once, as the information is desired for current manufacture. It will be important to know what arrangements will be made for furnishing copies of the tests for private information before they are published by the government.

The photograph, Fig. 3, shows a split head in which slag was found a short distance underneath the bearing-surface. This was at the junction of the columnar structure and central core. Fig. 4 shows a section which was porous and lost weight rapidly in the Fourth Avenue tunnel.

J. P. Snow, Boston, Mass.:—Mr. Howard's paper calls for suggestions as to profitable lines of inquiry that may be followed under the program. Recent experience with "crescent" breaks in rails seems to furnish an ideal field for these investigations. The rigid road-beds caused by the unusually cold winter of 1906–07 developed weak rails in unprecedented numbers, and a large majority of the resulting breaks were base-fractures of the crescent type.

In all of the rails that I have examined, the fracture started from a longitudinal flaw in the base, and burst out to the edges of the flange in a sort of conchoidal curve, having a cusp point on one part of the broken base and a corresponding re-entrant angle on the other. Oftentimes one side only of the base breaks out, producing a truly crescent or half-moon-shaped piece. When, however, the rail breaks clear through, the web and head are fractured exactly the same as in square breaks.

The longitudinal flaws from which these breaks commence are of all sizes, from the minutest speck to a visible seam many feet long. They appear to be of two distinct classes: 1, vertical seams with sides in close contact and mostly invisible to the unaided eye; and 2, seams generally oblique, very prominent, and frequently traceable on the base of the rail previous to fracture. The first class I shall call "gas-seams" and the second "rolling-flaws." The seams responsible for the breaks are in the surface of the base, but in the case of "gas-seams" the body of the metal throughout the base and head is full of these flaws. A fresh break from a very bad rail of this class shows a seamy surface, indicating a cleavage almost as free as a pine board. On a freshly-fractured edge the longitudinal seams show very plainly as silvery patches in the midst of the surrounding gray silky mass of the steel. These seams are described and shown in a paper by Mr. Robert Job before the New York Railroad Club.[1] Mr. Job was there discussing nickel-steel, and he attributed the seams to undistributed nickel, but the same defects are found in many cases in carbon steel.

Pieces may be easily broken from the bases of rails affected with either class of these defects, by standing them base up and striking them with a hammer on the side of the base. Sometimes a single blow will break out a crescent, but generally several blows are required. A sound rail cannot easily be broken in this way.

A study of these failed rails has been made at Watertown Arsenal by opening up the metal in a variety of ways and polishing and etching the surface so obtained. I have before you a sample so prepared. It is a piece of a rail that failed from a base fracture. The head and base have been planed into to different depths, the ends polished and portions of the

[1] *Proceedings of the New York Railroad Club*, vol. xvii., p. 514 (1907).

base cut out and broken in various ways. The head and base show many white streaks and some dark ones. The white streaks frequently have a fissure in their centers running exactly parallel to the rolling, and in the base and upper part of the head in vertical planes, that is, parallel to the axis of the rolls during the passes of the rails. At different depths of cutting these streaks are seen out of alignment with each other, showing that they occur individually throughout the mass of the metal as independent seams. The dark streaks are found only in the deeper cuts; they are wider and not so definite in outline as the white streaks, contain no manifest fissures, but have been proved to be lines of weakness, and seem to be the softer parts of the metal that lead to crushing and rapid wearing of the head. White streaks are almost indistinguishable in cross-section, while dark streaks show as round spots, blotches and streaks in the section of the head, web and base. They have been illustrated many times by Mr. Job and others.

The second class, or "rolling-flaws," occur only on the surface of the metal. The sides of these seams are blued like mill-scale, they are often strongly fluted, and are generally at an angle more or less inclined to the vertical. Fractures caused by these flaws oftentimes show sound homogeneous metal free from the silvery streaks and specks characteristic of that affected with gas-seams.

In former discussions I have taken the position that the phenomenon here called "gas-seams" was caused by gas-bubbles in the ingots. I am still of the same opinion. The "rolling-flaws" I believe to be due to cracks, tears or folds in the surface of the ingot or bloom.

An interesting fact was developed in a recent examination of a rail badly piped in the head. The pipe extended about two-thirds of the length of the rail. Pieces were broken from the flange with a hammer and but few "gas-seams" were found. More were found in the end of the rail not piped than in the piped end. Where the pipe was the worst it was quite difficult to split the flange. Is there any significance between the presence of the pipe and the absence of gas-seams? If gas-bubbles are the origin of the seams, might not a central pipe, by absorbing the gas in its vicinity, cause a local paucity of these seams?

A single instance like this proves nothing, but it indicates a lead the investigation of which may be profitable.

Illustrations of ingot-sections[2] show that gas-holes are commonly found in the steel ingots of commerce. Now, what becomes of these holes during and after rolling? They must be drawn out into seams parallel to the length of the bar and in planes parallel to the axis of the rolls. The gas contained in the holes must be forced into the adjacent metal. This may well affect the chemical composition of the walls of the seam and lead to the white streaks that we find in such abundance in rolled and forged steel.

The sequence between the gas-holes of the illustrations referred to and the "gas-seams" of our specimens, and between cracks and folds in the skin of ingots and blooms and the "rolling-flaws" in the bases of our rails, seems altogether logical to me, but it may not be satisfactory to all. It would seem to be entirely pertinent to the program laid out at Watertown to try to trace these flaws to their origin.

I hold that the case is fully proved, that crescent breaks are due to these longitudinal seams and flaws; hence, the first step has been taken in the solution of the three-sided problem presented by these breaks, the problem being: first, what defects cause the breaks; second, what generates these defects, and third, what will prevent the said generation.

The remedy for the trouble, whatever it may be, is, as Kipling says, "another story." Openings in low-carbon steels will weld up during rolling much better than those in high-carbon steels. We must, however, have comparatively high-carbon for rails. If gas-holes cannot be welded in this grade of steel, ingots must be cast in such a way that gas-holes will not be formed. Slow teeming at the proper temperature may suffice; sink-heads producing fluid compression may need to be resorted to; recharging with silicon, as advocated by Mr. Sandberg, may help; but it is hoped that some way will soon be found to manufacture rails substantially free from the manifest flaws which are proved to have led to such excessive breakage in the recent past.

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[2] C. L. Huston, Experiments on the Segregation of Steel Ingots in Its Relation to Plate Specifications, *Proceedings of the American Society for Testing Materials*, vol. vi., p. 182 *et seq.* (1906), and H. M. Howe, Piping and Segregation in Steel Ingots, *Bi-Monthly Bulletin*, No. 14, March, 1907, pp. 202, 240.

Tracing these flaws to their origin and studying a preventive for them seems to me to be a legitimate item of the program announced in the paper before us.

CHARLES S. CHURCHILL, Roanoke, Va. (communication to the Secretary *):—I have read over with much interest the paper of Mr. James E. Howard, Engineer of Tests, Watertown Arsenal, in reference to the program of tests under which current work of the Watertown Testing Laboratory is to be carried on.

The following terse statements are made therein:

"Broadly stated, each grade of steel, chemically considered, can have its tensile properties materially modified by ordinary methods of treatment in common shop use, some grades admitting of wider variations than others, but each admitting of substantial modifications. . . . So far as known, desired physical properties may be imparted to steel in its final stages by heat or mechanical treatment."

"The working temperatures, reductions in the rolls or under the hammer, and the number of passes in the rolls should be ascertained."

"In addition to questions on the influence of temperature on the final properties, there is also the question of interest as to how much or how little work at a given temperature is essential to accomplish the attainable changes in physical properties."

By way of discussion of this paper and of the subject in general, it seems to me that what is needed specifically just at this time, on the above lines, is more definite information as to the effect of different methods of rolling steel from ingot to bloom and from bloom to finished shape. It would be of great interest to know what are the resulting differences in steel under the following methods of treatment:

1. What are the characteristic differences in blooms of steel rolled from ingots under the following two methods?

A—A reduction of 38.5 *sq. in. per pass in seven passes from ingot to bloom during total time-interval of* 1 *min.* 15 *seconds.*

B—A reduction of 27.7 *sq. in. per pass in thirteen passes from ingot to bloom during a total time-interval of* 2 *min.* 15 *seconds.*

2. What are the resulting characteristic differences in finished steel rolled from blooms to finished shape, the shape being the same size, in the following two cases?

C—A reduction of 7.4 *sq. in. per pass in a total of eleven passes in rolling time of* 1 *min.* 45 *sec., with some delay before final pass sufficient to make the temperature of the finished steel the same as D.*

* Received Feb. 10, 1908.

D—A reduction of 4.7 sq. in. per pass in a total of eleven passes, in a total period of time of 3 min. 45 sec., the temperature of the finished product being the same as C, and the finished shape being the same as C.

But in the case of *D* the blooms have been reheated before rolling, whereas in the case of *C* the bloom was not reheated.

In this investigation it seems to me that one important matter to be determined as far as practicable is the relative amount of welding that has taken place in the segregated portion of the ingot—that is, the upper half thereof—as between processes *A* and *B*.

HENRY D. HIBBARD, New York, N. Y. (communication to the Secretary *):—The fact that the testing department of Watertown Arsenal, under the direct charge of Mr. James E. Howard, is at work with increased means on "tests of steel ingot-metal and derivative shapes" is most gratifying to all interested in the subject. The great and excellent work done by Mr. Howard in the past 30 years has added much to our knowledge of the properties of steel and other materials.

To the steel-metallurgist the statement from the program of tests that "a thorough, fundamental inquiry into the physical properties of steel . . . begins with the ingot metal" may seem to be somewhat inadequate, since much depends on the manipulation before casting, which may have a real if not recognizable effect on the steel. It is not easy to get a proper history of the metal before it is congealed in the ingot-mold, nor is it easy to interpret such a history if attainable, and discrepancies between what should reasonably be expected in steel and what is found will still be encountered, though in constantly decreasing frequency.

To illustrate this point, assume the case of a steel containing by analysis 0.02 per cent. of silicon. If the steel has been well made, and the silicon is all present as metallic silicon or as a silicide, all is well. But if the steel has not been well made, some or all of the silicon may exist in the metal as SiO_2. The amount of silicon reported by the chemist then may represent about 0.04 per cent. of SiO_2, or if it exists as a tribasic silicate of iron or manganese then 0.22 per cent. of that compound.

* Received Mar. 3, 1908.

Since the specific gravity of the tribasic silicate is about half that of iron, the 0.22 per cent. by weight will represent about 0.5 per cent. by volume in the steel, which is quite enough to account for much poor quality. Moreover, this 0.5 per cent. may be concentrated along the contact-surfaces between the grains or crystals of the metal in such a way that its effect on the properties is far greater than the proportion it bears to the whole. Chemistry fails us here, though the microscope may help, but if not, the discrepancy existing between the expected properties and those that are found can only be explained by the history of the metal while still liquid. If only a part of the silicon is present as SiO_2, the evil will be less than in the foregoing assumption, but a very little silica or silicate must have a deleterious effect out of all proportion to its relative amount.

The presence of silica and silicates in steel is better understood in Europe than in the United States, if one is to judge from the publications on this subject that have appeared in the technical press.

In order to compensate for the lack of the history of the metal under examination, Mr. Howard proposes that "the material and data should be had from sources where the highest skill now prevails in the art of steel-making." If this means that only the best grades of steel are to be studied there will still be much more to be done with inferior grades. The lessons to be learned from poor steels are of the greatest importance in their educational value.

Still, it may be desirable that the study of the best steels should be undertaken first to establish standards with which steels of poorer qualities may be compared. It is obviously beyond the capacity of any one committee or commission to cover the whole field in one lifetime.

Mr. Howard (communication to the Secretary*):—The members of the Institute have brought out many interesting features and valuable suggestions pertaining to the line of work now being conducted at the Watertown laboratory, and it is desired to express the deep appreciation felt for the aid which has thus been extended. Certain of the suggestions are already being acted upon, the status of the work in the laboratory permitting

* Received May 5, 1908.

taking early advantage thereof, while others will be availed of as rapidly as the tests advance.

In research work of this kind there are fundamental factors which influence the behavior of the material in its subsequent stages of manufacture or use, and it is noticed that due recognition is given such factors in the present discussion, while features of importance in current engineering practice have not been overlooked.

In acknowedging the indebtedness of the laboratory for the encouragement which the Institute is giving its work, advantage will be taken on this occasion to present some recently acquired data on one of the principal derivative shapes of ingot-metal—namely, steel rails. As is well known, a considerable number of rail-fractures have occurred in recent years, and it becomes a matter of deep interest to ascertain, if possible, what causes have contributed toward these unwelcome results. The severity of service-conditions has increased, without a doubt, and would in itself tend to induce early rupture of the rails, but still this is not all that might do so. The character of the fractures witnessed indicates that certain defects exist in the metal, the presence of which constitutes a menace to the integrity of the steel,

A type of fracture of frequent occurrence is the so-called "moon-shaped" fracture, in which a piece of the base of the rail is detached, as illustrated by Fig. 5. These fractures begin along the middle of their length, following a direction parallel to the axis of the rail for a longer or shorter distance, then changing their course by curving outward, detaching a fragment when the limit of fracture has reached the edge of the flange. The fracture shown in Fig. 5 was made in the testing-machine, on a piece of rail which had developed a moon-shaped fracture in service, the end of the service-fracture being also shown in the cut. A part of such a fractured surface is commonly striated, marking the incipient place of rupture; the balance of the surface presenting a granular appearance radiating from the initial portion. This type of fracture occurs in rails which contain longitudinal streaks, the fractures starting on the line of a streak.

Not infrequently several streaks are present in the same rail, in which case fracture, bending-moments being taken into

account, might be expected to occur along the one nearest the middle of the width of the base.

In Fig. 6 are shown the light- and dark-colored streaks in the base of a rail. The metal was planed off to the depth of a few hundredths of an inch, and the surface then etched with tincture of iodine. Surface-creases are sometimes present which have a circular direction, and in shape at least seem attributable to the action of the rolls of the rail-mill. Below such creases streaks are found.

Streaks are encountered in different parts of the rail. Fig. 7 shows longitudinal streaks found in the base of a rail which was planed off at six steps of different depths.

Streaks similar in appearance to those found in the bases are also present in the heads of the rails. Fig. 8 illustrates streaks in the head of a rail at depths ranging from 0.3 to 0.8 in. below the running-surface. The appearance of the rails illustrated by these photographs may be taken as representative of streaks as they are generally presented to the unaided vision, although characteristic differences are shown when they are magnified.

In Fig. 9 the familiar markings presented on the cross-section of rails are shown, and one streak viewed on the end is seen to extend in a longitudinal direction along the middle of the head. This view is presented to show the connection between the end-markings and the longitudinal streaks.

Fig. 10 is a view of the head of a rail, the running-surface of which has been planed off, and reveals a short longitudinal fissure which is on the line of a dark streak. This fissure was an interior one and did not appear on the surface before planing. It was occasioned apparently by wheel-pressures causing lateral flow of the metal, and which, encountering this plane of weakness, opened a split of short length. This example is taken to illustrate how a split head may result from streaked metal when the streak chances to be near the middle of the width of the head.

From the illustrations which have preceded it would appear that "moon-shaped" fractures in the bases and longitudinal splits in the heads may each, at times, be attributed to streaked metal in the rails.

So common are streaks in certain rolled and forged shapes

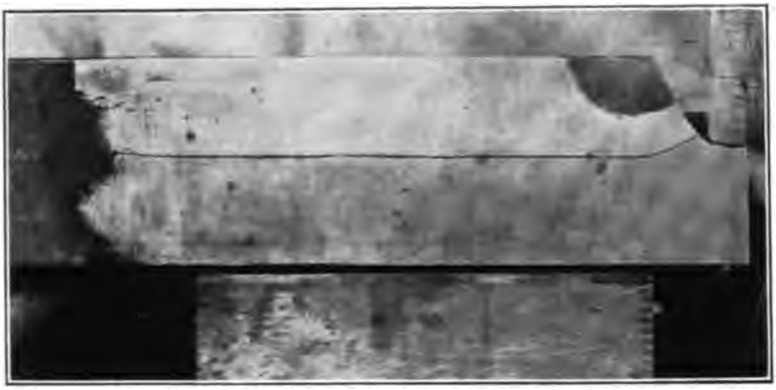


FIG. 5.—"MOON-SHAPED" FRACTURE IN BASE OF A STEEL RAIL.

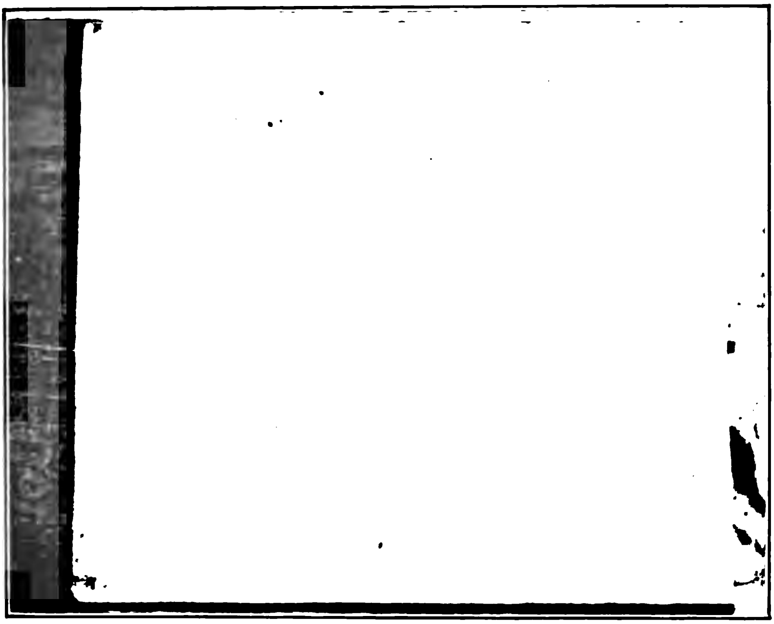


FIG. 6.—BASE OF STEEL RAIL, SHOWING LIGHT- AND DARK-COLORED LONGITUDINAL STREAKS.

Fig. 7.—Base of Steel Rail, Showing Longitudinal Streaks Found at Different Depths. Metal Planed off at Six Steps.

Fig. 8.—Head of Steel Rail, Showing Longitudinal Streaks Found at Different Depths. Metal Planed off at Six Steps.

FIG. 9.—END VIEW OF STEEL RAIL, POLISHED AND ETCHED, SHOWING MARKINGS ON CROSS-SECTION AND THEIR CONNECTION WITH LONGITUDINAL STREAKS.

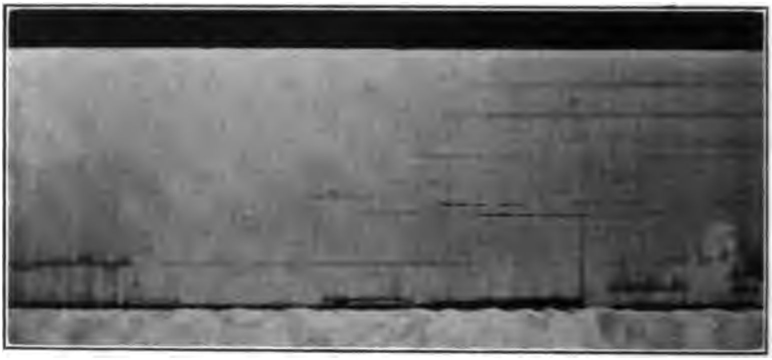


Fig. 10.—Head of Steel Rail, Planed Down, Showing a Short Split on the Line of a Longitudinal Streak.

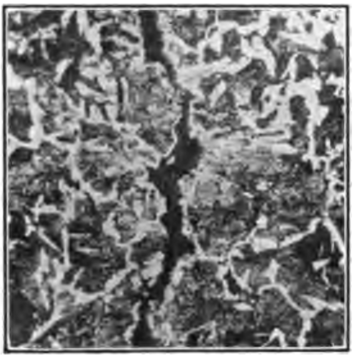


Fig. 11.—Initial State.

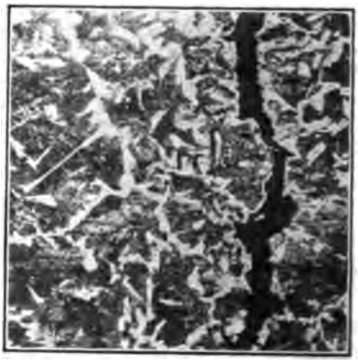


Fig. 12.—After Straining.

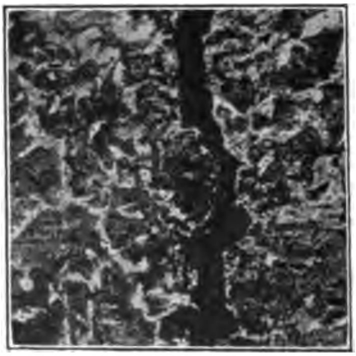


Fig. 13.—After Further Straining.

Figs. 11 to 13.—Manganese Sulphide Streak in Base of a Steel Rail. All Magnified 150 Diameters.

Fig. 14.—Photograph of Fractured Surface of Rail, After Having Been Ruptured in the Testing-Machine.

Fig. 15.—Cross-Section of Rail, Opposite End of Rail Shown in Fig. 14. Appearance After Polishing and Etching.

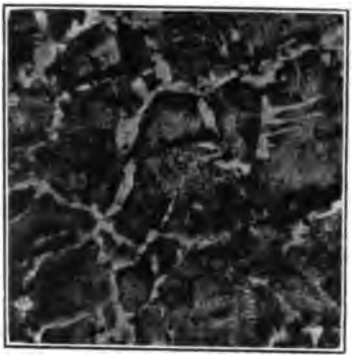


FIG. 16.—Unaffected Part.

FIG. 17.—Immediately Below Running-Surface.

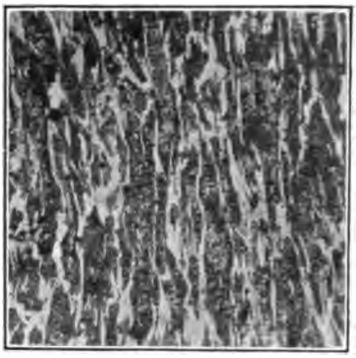


FIG. 18.—Fin on Edge of Head.

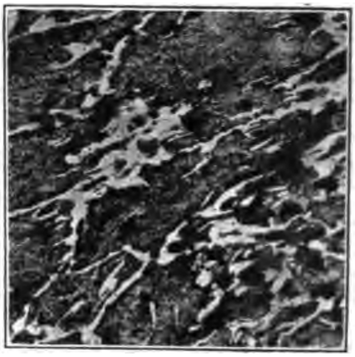


FIG. 19.—At Junction of Unaffected and Distorted Parts.

FIG. 20.—Structure after Annealing at Yellow Heat.

FIGS. 16 TO 20.—EFFECT OF WHEEL-PRESSURES ON HEAD OF STEEL RAIL. ALL MAGNIFIED 110 DIAMETERS.

FIG. 21.—RUNNING-SURFACE OF HEAD OF STEEL RAIL, SHOWING ROUGHENED SURFACE CAUSED BY SLIPPING OF WHEELS OF LOCOMOTIVES.

FIG. 22.—THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21. PART NEXT RUNNING-SURFACE. LONGITUDINAL SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

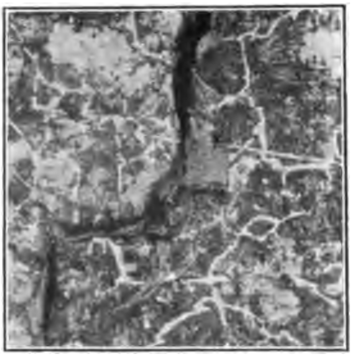


FIG. 23.—THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21. INTERMEDIATE PART. LONGITUDINAL SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

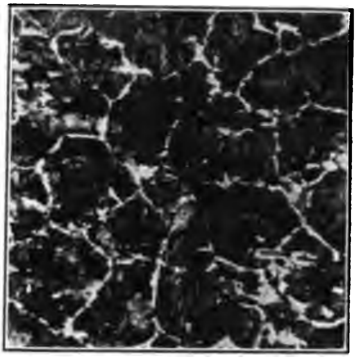


FIG. 24.—THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21. LOWER PART OF CRACK. LONGITUDINAL SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

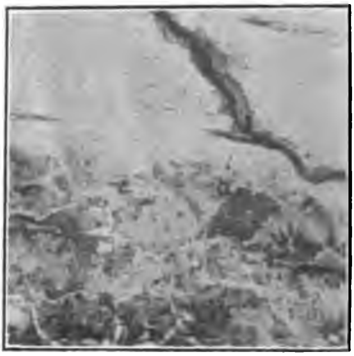


FIG. 25.—A SECOND THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21, CRACK NOT PENETRATING BEYOND HARDENED METAL OF RUNNING-SURFACE. LONGITUDINAL SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

FIG. 26.—THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21. TRANSVERSE SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

FIG. 27.—THERMAL CRACK IN HEAD OF RAIL SHOWN IN FIG. 21; INTERIOR CRACK IN HARDENED ZONE OF HEAD. TRANSVERSE SECTION OF RAIL-HEAD. MAGNIFICATION, 110 DIAMETERS.

that it is a matter of deep interest to inquire into the nature of streaked metal. Among the causes which introduce streaks may be mentioned entrained slag, manganese silicate, and manganese sulphide. In collaboration with Dr. Henry Fay, an examination was made of the base of a rail in which there were streaks of manganese sulphide in the steel. Three microphotographs, Figs. 11, 12, and 13, made during this examination, illustrate the appearance of the streak at three stages, from which the brittle character of the sulphide may be judged, and the readiness with which fractures in the steel may be caused without appreciable display of elongation, by loads applied at right angles to the direction of the streak.

Fig. 11 shows a streak of manganese sulphide in its original state as viewed on the cross-section of the base of the rail. Upon applying a comparatively small bending-stress, bringing this part of the base into tension, a fissure was caused in the sulphide, as shown by Fig. 12. Further straining of the metal enlarged the fissure, as shown in Fig. 13. This behavior seems to attach to the manganese sulphide properties detrimental to the integrity of the steel, since a fracture once formed in this substance readily extends through the rest of the rail, rupture being completed without the display of appreciable ductility. In the light of previous experience, manganese sulphide seems the most serious one of the three causes of streaks previously enumerated in promoting brittleness of fracture. This also is an interesting feature of the case, since some of the rails, notably those of early English manufacture which are very streaked, are reported to give good service in the track, even although of lighter weight than rails with which they are compared, these rails having streaks due to the presence of manganese silicate.

Fig. 14 is a view of the surface of the rail fractured in the testing-machine. The rail was loaded transversely, with the head on the tension side of the bend. Fracture began at the edge of the running-surface where a fin of metal had been formed by the flow of the metal under the wheel-pressures. Attention is invited to the radiant appearance of the fractured surface, the center of which marks the initial point of rupture. This appearance is generally so well defined in steel that the development of a fracture may be traced to its origin, a source

of material advantage not infrequently when judging of the causes of rupture.

Fig. 15 is the opposite end of the rail shown by Fig. 14, which was polished and etched. The markings on the surface are less pronounced than those usually displayed by rails. The shape of the head in cross-section suggests the flow of metal which took place when the rail was in the track. This flow necessarily produces a distortion of the microstructure, which effect extends to a depth of several hundredths of an inch below the running-surface. Impaired ductility characterizes the affected zone. Figs. 16 to 19 show the structure of the metal in the above rail. Fig. 16 is the normal, granular structure of the head; Fig. 17 shows the distorted shape of the grain immediately below the running-surface, at places along the middle of the width of the head; Fig. 18 shows the shape of the grain at the edge of the head—the metal composing the fin. At this place the metal has flowed so as to bring the longitudinal axis of the distorted structure into vertical position; Fig. 19 shows the structure at the junction of the distorted and the unaffected metal, the depth generally ranging from 0.03 to 0.06 in. below the running-surface.

Fig. 20 shows the subsequent structure of this rail after it had been raised to a yellow heat; the same structure pertained to the metal immediately below the running-surface as elsewhere in the head after this annealing had taken place. With this equalization of structure there was effected a restoration of the ductility of the steel, and the rail then displayed good bending-qualities with either the head or the base on the tension side.

The slipping of the wheels on the rail, such a movement as occasionally takes place with the driving-wheels of the locomotive when starting, in addition to roughening the surface intensely heats the metal. The appearance of the running-surface of a rail thus roughened is shown by Fig. 21, reproduced from an illustration in *Tests of Metals*, 1906. While a loss in ductility accompanies the flow of the surface-metal, a more serious result, which affects the integrity of the steel, results from the superficial heating of the head of the rail; the sudden cooling of the heated metal by conductivity of the cold metal below hardens the surface by its quenching effect, and, at the

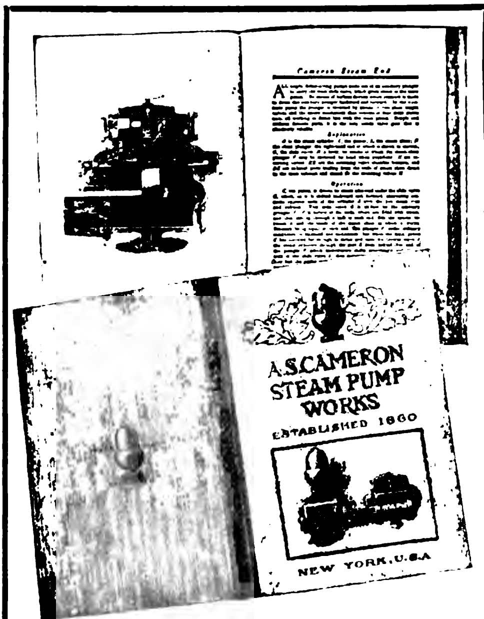
same time, the surface-metal is thrown into a state of tension. Cracks are, in this way, formed in the running-surface, which have a tendency to extend deeper into the metal, and may eventually end in complete fracture of the rail.

Figs. 22, 23, and 24 show different parts of the same thermal crack, one which had been made in the rail illustrated by Fig. 21. This crack appeared on the surface of a longitudinal section of the rail-head. Fig. 22 shows hardened metal at the immediate surface of the rail-head. This portion of the metal remained unetched by the reagent used, a 4 per cent. solution of picric acid. The inclination of the crack will be noticed, indicating the direction of the flow of the metal, preceding, doubtless, the hardened period. Figs. 22, 23, and 24 show this crack at successive depths.

Fig. 25 shows another thermal crack of lesser depth, one which has not extended through the zone of hardened metal. This crack was also found on the longitudinal section of the rail-head.

Figs. 26 and 27 represent thermal cracks viewed on a surface of the head, on a transverse section of the rail. These cracks therefore extend, in one direction, parallel to the length of the rail. The smaller crack of the two here illustrated was an interior one, which formed within the zone of the hardened steel.

It may be remarked that Dr. Fay found manganese sulphide on the walls of many thermal cracks of this rail-head. This result would seem to show that the sulphide caused lines of lower resistance in steel as regards both stresses applied to the cold rail and strains accompanying the changes in temperature during the hardening of the metal of the running-surface.



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